POULTRY SCIENCE

March, 1937, Vol. XVI, No. 2

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Poultry Science Association

University of Wisconsin
Madison, Wisconsin
August 10-13

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Plan of Sessions

By action of the Directors of Poultry Science Association, sessions of the Association this year will be from 9 to 12 a.m., and 1:30 to 4:30 p.m. The business meeting of the Association will occupy the time Friday morning, August 13. Tuesday afternoon, August 10; Wednesday morning, August 11; Thursday morning, August 12, and Friday afternoon, August 13, will be devoted to a general program, wherein there will be presented papers of greatest general interest selected from the various sections. Wednesday afternoon, August 11 and Thursday afternoon, August 12, will be devoted to meetings of the sections at which time papers of special interest to those sections will be presented and discussed.

POULTRY SCIENCE

March, 1937, Vol. XVI, No. 2

Hatchability as Related to Seasons and Hour of Laying[1]

F. A. HAYS

Massachusetts State College, Amherst, Massachusetts

(Presented at Annual Meeting, August 1936; received for publication August 14, 1936)

PROBLEMS in hatchability have been studied by a large number of workers including Pearl, Dunn, Hutt, Jull, Warren, Waters, Byerly and Dove as well as many others, reported in Jull's *Poultry Breeding*, 1932. Under uniform conditions of incubation, the greater proportion of evidence indicates that the genetic makeup of the female and of her mate largely determine the percentage of fertile eggs that will hatch. Malposition and a few lethal genes are known to increase embryonic mortality. Byerly, Knox and Jull (1934) express the opinion that the inheritance of hatchability must be determined by a very large number of genes.

Recently Dove (1935) and Waters (1935) have demonstrated that the lethal effects of malposition have probably been exaggerated. Both of these workers have shown that normal chicks assume these so-called abnormal positions as a phase of normal development between the eighteenth day and the hatching day. In view of this fact both workers conclude that many dead chicks that are found abnormally oriented in the egg have died at a particular stage in embryological development not as a result of position in the egg but from other causes.

Examination of thousands of eggs that have failed to hatch at this Station reveals many embryos both living and dead that show no visible abnormalities. No other cause than lack of vigor can be assigned for this large proportion of embryos which never emerge from the shell. Data on the Massachusetts flock as well as from other workers indicate that inheritance plays a large part in determining the percentage of embryos that will hatch normally.

DATA AVAILABLE

Data are available on the hour of laying and the complete hatching record of Rhode Island Red females covering the years from 1916 to 1935. Hatching records for 1926 are omitted because dipping the eggs in an oily disinfectant apparently made the hatching records abnormal. The records include 985 hens and 1,557 pullets that laid a minimum of ten eggs during the 56-day hatching period. From 1916 to 1932 the eight weekly hatches occurred between March 25 and May 15. From 1933 to 1935 the eight hatches took place three weeks earlier giving four hatches in March and four in April.

[1] Contribution No. 271 of the Massachusetts Agricultural Experiment Station.

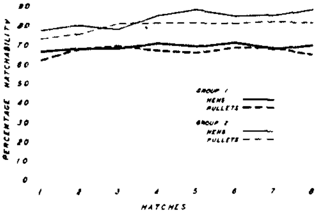

CHART 1. Relation of hatching date to hatchability.

The incubators used in the earlier period were lamp machines through 1929. A double deck water heated machine was used from 1929 to 1932. In 1932 the water heated machine was supplemented by a compartment electric machine. Since 1933 an electric cabinet machine has been used exclusively. The electric cabinet machine has proved much more efficient than any of the machines previously used. Incubation conditions have always been far from ideal because of low cellar temperatures.

OBJECTS OF STUDY

There are two primary objects of this study: First, the relation of season to hatchability of fertile eggs; Second, to determine the possible relationship between the hour of laying and fertility of eggs, early embryonic death rate, late embryonic death rate and the percentage of fertile eggs that hatched from hens and from pullets.

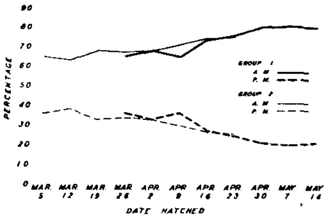

CHART 2. Proportion of forenoon and afternoon eggs laid.

RESULTS OF INVESTIGATION

For purposes of study the hatches obtained from 1916 through 1932 are included in group I and the hatches from 1933 to 1935 as group II. All females used for breeding in their first laying year are classed as pullets and all yearling or older females as hens. Eggs used for each hatch were laid during a seven-day period previous to incubation.

1. *Hatching Date and Hatchability*

Chart 1 presents the percentages of fertile eggs that hatched in the eight weekly hatches. In group I both hens and pullets showed a slight increase in hatchability as the season advanced. This increase was slightly more pronounced with hens. When group II is considered there was a somewhat greater increase in hatchability as the season advanced. Hens gave a marked improvement in hatchability through the season while pullets showed no change after the first two hatches. The charts are based on 12,686 fertile eggs laid by hens and 21,404 fertile eggs laid by pullets in group I and on 3,842 fertile eggs from hens and 7,208 fertile eggs from pullets in group II. These rather extensive data indicate that eggs from hens were more affected by seasonal

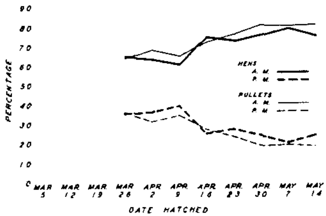

CHART 3. Proportion of forenoon and afternoon eggs laid by hens and by pullets, group 1, 1932.

conditions than were pullet eggs and that under the conditions of incubation used late hatching did increase hatchability.

2. *Proportion of Forenoon and Afternoon Eggs*

Before undertaking the study of the relation of hour of laying to fertility, embryonic mortality and hatchability it is desirable to ascertain the proportion of forenoon and afternoon eggs that were produced by hens and by pullets. All eggs laid up to 12 noon were classed as forenoon eggs and those laid after 12 noon we considered afternoon eggs.

The percentages of forenoon and afternoon eggs were recorded for each setting.

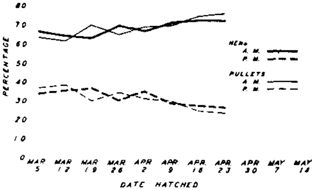

CHART 4. Proportion of forenoon and afternoon eggs laid by hens and by pullets, group 2, 1933.

Chart 2 illustrates the changes in proportions of morning and afternoon eggs as the season advanced. When the days were short in February only about 65 percent of the daily eggs were laid by noon. This was followed by a linear increase in the proportion of morning eggs up to early April. The rate of increase in the proportion of morning eggs was the same in both groups.

The proportions of morning and afternoon eggs set from hens and from pullets may be compared in charts 3 and 4. Chart 3 shows that pullets in group I laid a slightly greater proportion of morning eggs compared with hens through the hatching season. The rate of change in proportions of morning and afternoon eggs with advance

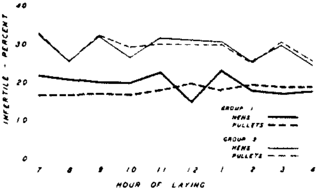

CHART 5. Hour of laying and percentage of infertile eggs.

of the season was the same in hens and pullets.

The somewhat greater portion of morning eggs laid by pullets in group I is very little in evidence in group II. Chart 4 shows that hens and pullets lay about the same proportions of morning and afternoon eggs from early February to late April. Between these dates there is a linear increase in the proportion of morning eggs.

In view of the data presented in charts 2, 3 and 4, the more rapid increase in the hatchability of hens compared with pullets with advance of season shown in chart 1, cannot be explained on the basis of different proportions of morning and afternoon eggs laid by hens compared with pullets.

3. *Hour of Laying and Infertility*

Chart 5 presents the percentage of infertile eggs laid at ten different hours during the day. Infertility was about 10 percent

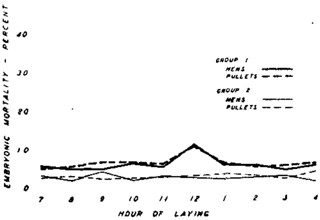

CHART 6. Hour of laying and embryonic mortality to five days.

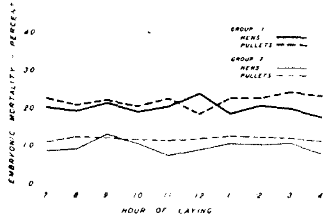

CHART 7. Hour of laying and late embryonic mortality.

higher for both hens and pullets in group II showing that cold winter weather is inimical to high fertility under the housing conditions used. The data show that both hens and pullets of group II had almost identical infertility. There were minor fluctuations from hour to hour but there was no significant change in infertility through the day. Eggs laid by the hens of group I in the forenoon gave somewhat higher infertility than pullet eggs laid during the same hours. Pullet infertility in group I increased very slightly in the eggs laid after ten o'clock. In general, the data show no very significant relationship between hour of laying and infertility in either hatching group.

4. *Hour of Laying and Early Embryonic Mortality*

Embryos that died by the fifth day of incubation are classed as early deaths in this

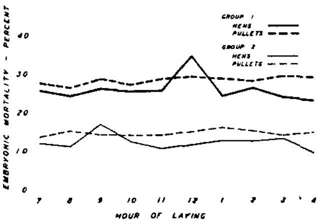

CHART 8. Total embryonic mortality.

study. Possible relations between hour of laying and early embryonic mortality are depicted by chart 6. All percentages are based on the total eggs set. Mortality was much higher in group I probably due largely to less efficient incubators used in the earlier years. In group I eggs laid by pullets during the morning hours gave a slightly greater mortality than hen eggs laid during the afternoon. No explanation is available to account for the high mortality for eggs laid during the noon hour in the late hatch group. With more efficient incubation to produce the early hatch group, there was essentially no relation between the hour of laying and embryonic mortality. Pullets and hens also behave in the same general way.

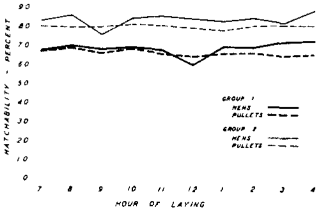

CHART 9. Hour of laying and hatchability of fertile eggs.

It seems probable that under an efficient system of incubation that the hour when eggs are laid does not affect early embryonic mortality.

5. *Hour of Laying and Late Embryonic Mortality*

All embryos that died after the fifth day of incubation and all those that failed to emerge from the shell are lumped together in the late mortality class. Chart 7 shows that pullets gave a somewhat greater embryonic mortality than hens in both groups. The data showed no significant relation between hour of laying and late embryonic

mortality in either hens or pullets. These results are not in agreement with those of Hutt and Pilkey (1930) who found that late mortality in embryos was higher in afternoon eggs than in eggs laid before 9 a.m. These results do agree with those of Nicolaides (1933) even though his data are calculated on the individual hen basis.

6. *Hour of Laying and Total Embryonic Mortality*

Chart 8 presents the total embryonic mortality for the entire incubation period. In group I there is considerable fluctuation between hours and pullets show a greater mortality than hens. There is, however, no evidence that hour of laying affects embryonic mortality. In group II mortality is very constant from hour to hour and about 10 percent lower than in group I. Hens and pullets also gave about the same mortality rates. These data clearly show the effects of poor incubation on embryonic mortality. All re sults in these sudies indicate that hour of laying has no effect upon embryo mortality.

7. *Hour of Laying and Hatchability of Fertile Eggs*

Chart 9 presents the summarized data on hatchability of fertile eggs on the basis of hour of laying. Hen mothers in group I showed an insignificantly higher hatchability in the afternoon eggs. Pullets showed no relation between hour of laying and hatchability. In group II hens gave a significantly higher hatchability than pullets but no significant relation between hour of laying and hatchability. Pullets gave a very constant hatchability from hour to hour.

SUMMARY

Hatching records covering twenty years are reported considering the relation between the hour that the eggs were laid and infertility, early embryonic mortality, late embryonic mortality, total embryonic mortality and percentage of fertile eggs that hatched. The percentages of fertile eggs hatching through the season is also reported.

1. Hatchability increased through the hatching season for hens but not for pullets.

2. The proportions of forenoon and afternoon eggs laid through the hatching season did not differ from hens and pullets.

3. Hour of laying does not affect infertility.

4. Hour of laying had little or no effect on early embryonic mortality.

5. Hour of laying did not modify late embryonic mortality.

6. Total embryonic mortality was independent of hour of laying.

7. Hatchability of fertile eggs was not affected by hour of laying.

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Light in Relation to the Experimental Modification of the Breeding Season of Turkeys[1]

H. M. Scott and L. F. Payne
Kansas State College, Manhattan, Kansas

(Received for publication, August 17, 1936)

Among the domesticated farm birds, the reproductive cycle of the turkey bears the most striking similarity to that of birds in the wild state. The turkey is therefore, very favorable material for studies relating to the experimental modification of the breeding season.

Sexual periodicity is fixed from year to year among wild birds although climatic conditions may fluctuate widely with respect to inception and severity. The incidence of daylight and darkness is, however, the most constant of the environmetal factors. These facts led Schäfer (1907) to conclude that the length of the day influences the sex-cycle of birds. Rowan (1928) concluded that sexually inactive juncos could be made sexually active by forced muscular work. Bissonnette (1930), however, failed to activate the germinal elements of the starling's testes by induced muscular work during the months of December and January when they are normally quiescent. Irradiation, however, with a 60-watt incandescent bulb resulted in active spermatogenesis after six weeks of treatment. In subsequent works Bissonnette (1931a) has been able to show that the response to irradiation is not to be explained on the basis that the birds have a longer period over which to feed; that the relative period of exposure to artificial light in relation to that which the birds were receiving previously and not absolute light determines the course of the action on the sex-gland; (1931b) that the response of the starling's testis is conditioned by the intensity of light and (1932a) by the wave length of the visible spectrum. He was able to show that red light with the longer wave-lengths stimulated the dormant testes of starlings to sexual activity whereas green light of the shorter wave-lengths inhibited or retarded this action.

Kirschbaum and Ringoen (1936) have shown that the spermatogenic activity of the sparrow's gonads is closely associated with the incidence of daylight.

The experiments reported to date have been concerned with the male sex in which the response has been measured by the enlargement of the gonad and/or its histological appearance. In no instance has our attention been called to the female, removed from the wild state and subjected to artificial light, being induced to ovulate and lay in advance of the normal breeding season. Throughout his work, Bissonnette has observed that in Aves, the males responded more quickly to variations in light than did the females whereas the reverse is true for mammals (Ferrets) and, as has been suggested by Bissonnette (1932b), this reversal in response may be due to the fact that in birds, the males and in mammals the females are homozygous for sex and homogametic. Although the follicles have enlarged and the oviducts have been observed to undergo marked hypertrophy when wild birds were subjected to artificial light in

[1] *Contribution No. 102 from the Department of Poultry Husbandry.*

advance of the normal breeding season, in no instance has ovulation been reported.

Warren and Scott (1936) have studied the influence of light on the reproductive cycle of the sexually mature fowl. They concluded that the onset of darkness was in most instances responsible for the termination of the clutch. It was demonstrated that hens subjected to continuous artificial light could be induced to ovulate and lay throughout the 24-hour period.

It has long been known by poultrymen that egg production could be sustained at a higher level during the fall and winter months, when the hours of daylight are decreasing rapidly if in addition to solar irradiation, the flock is illuminated with artificial light. The benefits resulting from such a practice have been attributed to: (1) increased food consumption and (2) increased muscular activity. Bissonnette has shown, however, that the onset of sexual maturity in wild birds is not conditioned by these factors. Whetham (1933) has investigated the shape of the egg production curve of the hen at different latitudes throughout the world and has found a close correlation between the daylight curve and the egg production curve although the upward trend of the latter tended to precede that of the daylight curve. Thus, at latitude 45° N. the greatest production per bird (16.9 eggs) occurred in March. The average hours of daylight for this month was 11.48 hours and for February 10.20 and April 13.24 hours while the maximal hours of daylight (15.34) was in June. At latitude 35° S. September was the month of greatest production. During this month the average hours of daylight was 11.48 and for the months of August and October 10.42 and 12.52 hours respectively. Here at this southern latitude December has the greatest number of hours of daylight. It is significant that the month or months of greatest production, for the seven groups north of the equator and the four groups south of this point, followed periods when the number of daylight hours was at its lowest level. Moreover, her data show that in most instances the months of greatest production had on an average, approximately 11.5 hours of daylight. These results led her to conclude that the response of the hen to an increased light ration may be explained on the same basis as that of the response of wild birds subjected to increased doses of light during the normal period of gonadal inactivity and that relative light and not absolute light is the causative factor.

In the latitude of Manhattan, Kansas (39° N.) a flock of spring hatched turkeys of average breeding will reach sexual maturity during the first three weeks of March. In no instance during the past nine years has an individual female in the station's flock that has not been subjected to artificial light, attained sexual maturity earlier than March 4 although frequent attempts have been made to alter this by modifying certain management and feeding practices. Thus, it appears quite certain that the reproductive cycle of the turkeys used in these experiments is characteristic of that of birds in the wild state.

The Nebraska Agricultural Experiment Station (1930) reported that artificial illumination used February 1 in advance of the natural laying season caused the lighted group of turkeys to lay approximately one month earlier than the control group receiving no lights. Similar results have been reported by Albright and Thompson (1933) and by the United States Range Livestock Experiment Station (1933).

A number of light experiments have been conducted at this station during the years 1934-36 and three of these experiments are reported at this time. Previous to this a number of preliminary trials had been conducted which demonstrated that the egg laying cycle could be modified by artificial

illumination. The results of these preliminary trials also served as a basis for the planning of the experiments reported herein.

THE POSSIBLE INFLUENCE OF EXPOSURE TO THE ELEMENTS OF WINTER

In the preliminary experiments it was thought that the housing of the birds and thus protecting them from the severe elements of winter as well as lighting, might have caused the sex-organs to reach sexual activity approximately eight weeks in advance of the normal laying season. To study the possible interrelationship of these two factors, a flock of 30 Narragansett female turkeys hatched May 6, 1933, was divided into three groups on December 1, 1933. One group was placed in one-half of a 14′ x 28′ open front poultry house and confined there throughout the winter and breeding season. This lot received morning light from one 60-watt incandescent bulb with no reflector, daily from 4:30 a.m. to daylight for the period December 1, 1933, to February 1, 1934. From February 1 the light ration was decreased 15 minutes each week until April 1 when it was permanently discontinued. A second lot was placed under the same experimental conditions except they received no morning lights, to serve as inside controls. The third group remained on the open range throughout the winter and breeding season and was used as the outside controls. The experiment terminated May 25, 1934. No attempt was made to restrict the length of the feeding period in any of the groups and all lots received the same food constituents.

If protection from the severe elements of winter and the increased light ration are factors contributing to the experimental modification of the breeding season and their effects are cumulative, then the groups should have reached sexual maturity in the order of the lighted and housed group, the housed but unlighted group, and finally the range group receiving no supplementary protection or light. The first egg was laid January 3, 1934, 34 days after the light had been added, by a pullet receiving the increased light ration. This female was 242 days of age at sexual maturity. Four of the inside control pullets laid on March 9 at 307 days of age while one of the outside control pullets laid one day later. Thus, it has been shown experimentally that the role played by such environmental factors as temperature is a minor one, if any, in altering the breeding season of the turkey. This is in confirmation of Bissonnette's work with starlings and is also in agreement with the results obtained under farm conditions since the severity or mildness of the winter and early spring months appears to neither hasten nor retard the breeding season. The percentage production by weekly periods for the three groups has been plotted in Figure 1. All groups reached their greatest production during the fifth week of their respective laying periods as shown in the upper graph where the data points have been plotted at equivalent periods.

The average production of desirable hatching eggs per female was 68.6, 36.4, and 40.1 for the lighted, inside controls, and outside controls respectively, while the percentage production was 46.8, 43.3, and 47.7.

DOES THE TURKEY EXHIBIT WAVE-LENGTH SPECIFICITY?

While Bissonnette has shown conclusively that the response of the starling is conditioned in part, at least, by the spectral character of the light, it does not necessarily follow that all genera of birds will react to the stimulus of light in the same way. Thus, attempts to hasten the onset of sexual maturity in the female guinea fowl by augmentations of light have been futile to date.[2]

[2] Unpublished data from the Kansas Agricultural Experiment Station.

For this phase of the investigation four lots of 12 female turkeys and one male hatched May 15 were confined on November 30 to the quarters previously described. Three of the groups received supplementary light while the fourth lot served as inside controls. No outside control group was used since the earlier work had demonstrated that it was unnecessary. Uniform Miller lighting fixtures were used in the three lighted pens consisting of 200-watt Mazda bulbs and 18-inch porcelain lined reflectors. The light was located 5 feet above the floor and directly over the feed hoppers. The light filters used were obtained from the

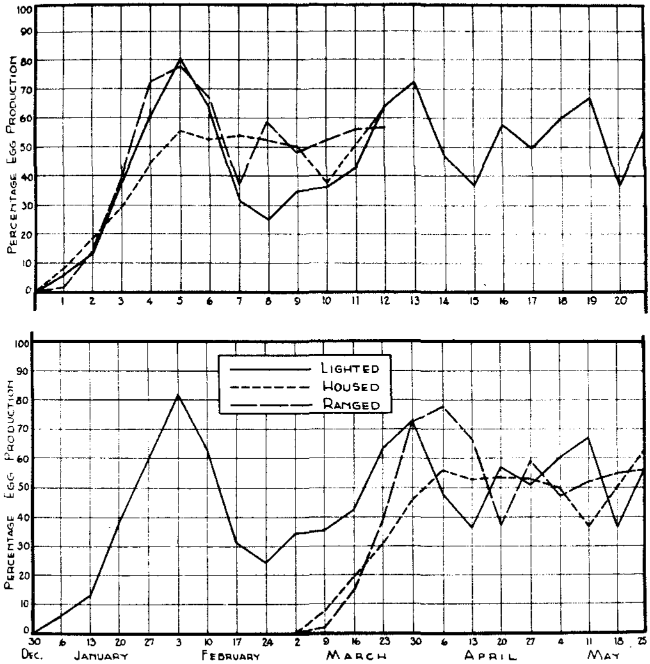

FIG. 1. The effect of morning lights and management on age at sexual maturity and on distribution of egg production. In the upper graph, the data points have been plotted at equivalent periods.

Corning Glass Works. To remove the longer wave-lengths, the Signal Blue No. 556 filter was selected. The maximum transmission of this filter is in blue at approximately .425 μ and according to the specifications the approximate range extends from .330 μ to .530 μ. It, therefore, transmits an insignificant

amount of ultra-violet. Of the visible spectrum, violet, blue, and green are transmitted while yellow, orange, and red are filtered out.

To remove the shorter wave-lengths the Signal Red filter No. 243 was employed. This filter gives 40 percent of its trans-

1. White light or the entire visible spectrum.

2. Red light or the longer wave-length exclusively.

3. Blue light in which the red end of the spectrum was screened out.

From December 1 until April 18 the

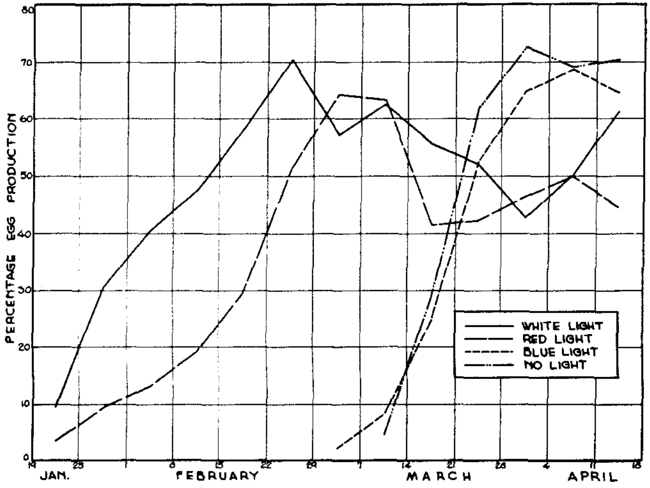

FIG. 2. The response of turkeys to light of different wave-lengths.

mission at .622 μ and only 5 percent at .608 μ. It is a much sharper filter than Signal Blue, transmitting the red and only a fraction of the orange. Orange, yellow, green, blue, and violet are filtered out. Each filter was 6½ inches square and two such filters were placed in each reflector. The installation of these filters reduced the area through which light could pass from 254 to 84 square inches. In the three lots receiving supplementary light, the spectral character of the lighting condition was as follows:

groups were subjected to these different lighting conditions from 4:30 a.m. until 7:00 a.m. each day. The feeding period for all groups was equalized by not permitting any of the groups to have access to water or food until after daylight.

As shown in Figure 2 the females in the white light pen and the red light pen reached sexual maturity in the later part of January whereas the control group and the group irradiated with the shorter wave-lengths (blue) did not start laying until March. January 21, January 24, March 6,

and March 10 were the dates of sexual maturity for the white, red, blue, and no light groups respectively. The results of this experiment would indicate that the wave-length of light is a conditioning factor in the sexual periodicity of turkeys and that the longer wave-lengths stimulate while the shorter ones neither hasten nor retard the onset of sexual maturity. In this experiment, however, no attempt was made to control the light flux. Thus, the illuminating power, measured by a "Weston Photronic Foot-candle Meter" directly under the light and 28 inches from the floor was 57, 14, and 1 foot candles respectively for the white, red, and blue lights. While the visibility was poor in the blue light pen, the illumination was sufficient enough to permit the birds to move about freely. It was observed that the birds in the blue light pen were not so active as the birds in either the white or red light pens when the lights were turned on in the morning. They were slower alighting from the roosts and when once on the floor, they were not so alert as the birds in the other two lighted pens.

It is interesting to note (Table 1) that food consumption varied but little during the first four weeks of the experiment for the various groups and only a slight increase in food consumption for the white and red light groups over the blue and no light groups during the second four weeks of the experiment. Attention is called to the marked decrease in the level of food intake during the last eight weeks of the trial. This is a possible explanation for the tremendous loss in body weight that turkeys sustain during the breeding season.

TABLE 1.—*Pounds of Feed Consumed per Bird at Four-week Intervals.**

Period	White light	Red light	Blue light	No light
11-30 to 12-28	12.69	13.54	13.23	11.55
12-28 to 1-25	15.16	15.07	12.84	12.61
1-25 to 2-22	20.46	11.99	13.24	16.69
2-22 to 3-21	12.05	10.08	13.69	12.00
3-21 to 4-18	9.49	9.06	9.41	10.15
Total	69.85	59.74	62.41	63.00

* Mash, grain, and shell are included in these totals.

ADDITIONS OF LIGHT DURING THE DAYLIGHT PERIOD

In our experiments as well as the experiments that have been conducted by others, the day has been extended by the addition of light to the normal day period. These increments have been made before sunrise or after nightfall or both as carried out by nature. If, as Whetham has suggested, artificial light compensates for the deficiencies in the solar irradiation and in this way stimulates the sexual activity of the bird, it is possible that the same result could be obtained by daylight irradiation. To test the validity of this hypothesis, four lots of 11 females and one male were placed in the pens December 1. The stock had been hatched the previous May. The lighting conditions were the same as described for the previous experiment with the exception that the birds were illuminated from 7:30 a.m. to 11:30 a.m. daily starting December 8. On clear days, the interior of all pens was illuminated with 70 to 80 foot candles of solar light. To this would be added the candle power arising from the artificial light in the pens receiving supplementary light.

In all pens the first eggs were laid between the dates of March 9 and March 12. Individuals in the blue light and white light

pens reached sexual maturity March 9, in the red light pen March 10, and the control pen March 12. It is apparent that additions of light made during the daylight period does not give the same response as when this light is administered so as to give a longer period of daylight. The stimulus to be effective, must operate over a longer time than the normal day period. It is possible that the turkey, and birds in general, can absorb or utilize just so much light per unit of time. It is also true that in the stimulus-response reaction, additions of light made during the dark period give a greater relative stimulation than the same quantity of luminous flux when it is administered in the presence of an already existing high luminous intensity.

SUMMARY

1. The reproductive cycle of the turkey can be modified by the use of artificial illumination. Turkeys which normally reach sexual maturity in March can be made to lay in January by the use of morning lights starting December 1.

2. Evidence is presented to show that what would be considered proper housing and protection exerts no influence on the sex-cycle of the turkey. Turkeys housed and unlighted do not reach sexual maturity any earlier than do turkeys ranging and roosting in the open.

3. Female turkeys subjected to unfiltered white light or the longer wave-lengths of red light only, were stimulated to sexual activity several months in advance of the normal breeding season. The shorter wavelengths (blue light) failed to exert any influence on age at sexual maturity.

4. The increased light ration rather than the lengthened feeding day appears to stimulate the early ovarian activity of the turkey.

5. Turkeys failed to respond to light that was administered four hours each day during the normal period of daylight.

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Agricultural Extension in the Field of Adult Education

H. W. NISONGER
College of Agriculture, Ohio State University, Columbus, Ohio

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BEFORE beginning the discussion of agricultural extension in its relationship to the whole field of adult education, I want to pause long enough to pay a word of tribute to the distinguished record of accomplishment which has been made in poultry extension. During the last two decades farmers have been continually learning from poultry extension workers how to increase egg production through the application of science to selection, feeding, breeding, and management of their laying flocks. They have learned how to shift the seasonal production of eggs, how to use modern brooding equipment, and how to apply principles of sanitation to the handling of large units of birds. Under their direction, hatcherymen have been able to develop successful breeding programs and to control diseases in commercial incubation.

Poultry extension workers have also assisted in improving the market quality of poultry products and in the dissemination of economic information on production and consumption trends. They have pointed out the need for better marketing methods and have assisted in the organization of marketing machinery and in the follow-up education. And that is not all.

Poultry extension workers have shared with the other workers in agricultural extension in developing the largest and most effective single adult education agency in the world. They have pioneered in the creation of methods and techniques of informal adult education and have become highly skilled in using these methods and techniques in the education of rural adult people. The results speak magnificently for themselves.

Concurrent with these developments in extension work we find that things have been happening in other sectors of the adult education field. Some of these new ventures in adult learning have been called by strange and curious names such as, public forums, alumni colleges, federal emergency classes, radio colleges, peoples institutes, education in the CCC camps, workers education, hobo schools, folk schools, opportunity schools, parent education, little theaters, and so on through a long list. Perhaps some of these ventures may prove to be of only passing importance yet I am convinced that we have for the first time in this country an adult education movement in the making. To be sure it is different from the folk school movement in Denmark or the workers education movement in Great Britain. Nevertheless it is a movement which is significant and which has already reached considerable magnitude and scope.

We are told that during the year 1934 approximately 22½ millions of people were reached through some kind of program of adult education. This means that nearly one out of every three adults in the United States is being exposed at least to some form of adult education. In 1924 it was about one out of every five. This represents a substantial gain in the 10-year period.

As you already know a large number of agencies claim representation in this field.

The 1936 Handbook of Adult Education gives space to 170.[1] Most of these agencies are national or state-wide in character and their programs reach down into local communities. Some however are relatively unimportant at present, either because they reach few people or because their programs are limited.

Out of this long list there are nine agencies or groups of agencies which at present are reaching the majority of the people enrolled. In 1934 these nine agencies each reached the following numbers,[2]

Agricultural extension	6,000,000
Radio education	5,000,000
Emergency education	2,250,000
Recreation (indoor)	2,000,000
Public schools	1,500,000
Library adult education	1,000,000
Men's and women's clubs	1,000,000
Private correspondence schools	1,000,000
Lyceums and chautauquas	1,000,000

It is interesting to note in passing that all of the above agencies, except the last two, have made tremendous gains in numbers reached during the 10-year period. During this period private correspondence schools have lost one-half and lyceums and chautauquas have lost two-thirds of their former enrollments.

What is the significance of this surge of interest in adult education? Is it merely a passing fancy or is it something which is likely to grow with time?

There are probably many reasons for this growth of adult interest in education but the following three will illustrate.

1. The depression period has awakened us to a realization of the complexity of modern society. During this period our people have come face to face with the realities of lowered incomes, unemployment relief, increased living costs, higher taxes, increased governmental activity, proposals for social security, court decisions, and so on through a long list of problems. Thousands of people have attended forums, joined discussion groups, and have patronized libraries in an honest effort to better understand what is going on all about them.

2. During the last few years a large section of our population has been faced with an increasing amount of forced leisure due to a reduction in working hours and to unemployment. Available programs of adult education have been expanded, and new ones set up in order that people might use their time as profitably as possible and also, to avoid the dangers which accompany idleness.

3. We are rapidly changing our ideas about the purpose of education. There is in this country a growing conviction that if our people are ever to become intelligent in meeting the problems of a democracy, education must be a continuous process throughout life. We once thought we could cram enough education to last a lifetime into those years when youth sits in the classroom. We now realize that is impossible because:

a. Social change goes on so rapidly that we cannot anticipate what a child will face when he becomes an adult.

b. It is a wasteful process to attempt to teach children to deal with many adult problems before they have a chance to face them as adults.

The most promising solution to this problem appears to be to supplement the more formal education with some kind of continuous program of adult education. Certainly our social life is not going to be much less complex in the near future and people will probably continue to have an abundance of leisure time, although we hope for a better distribution. This will doubtless mean that the interest in adult education

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[1] Handbook of Adult Education, American Association for Adult Education, 60 E. 42nd Street, New York, 1936.

[2] Cartwright, Morse A., Ten Years of Adult Education, American Association for Adult Education, New York, 1936.

will continue to increase for some time to come and that new programs will spring up.

What bearing will the continued growth in the field of adult education have on agricultural extension? What adjustments must extension make in order to meet the new situation?

1. As agencies engaged in adult education working in a given area expand, they must work more closely together in planning their programs in order to prevent overlapping and conflict. For example the United States Commissioner of Education is urging public school officials to organize forums for the discussion of public questions. The Secretary of Agriculture is also urging county extension workers to organize forums for the discussion of problems relating to agriculture and rural life. In one county in a nearby state I am told that both the county superintendent of schools and the county agent had county wide forum programs set up and had announced the first meetings before the one discovered what the other was planning to do. This will inevitably lead to serious conflict.

I recall most vividly some of the difficulties we encountered in the early days of vocational agriculture when the teachers began to offer evening courses for adult farmers. I have seen a county agent plan for a series of poultry meetings in a community and the teacher of agriculture plan for an evening course in poultry in this same community, neither one knowing what the other intended to do. It has been fairly easy to straighten out these difficulties since the number of departments of vocational agriculture is small but it may not be so simple when three-fourths or more of our rural communities have such departments.

In the past the public schools as a whole have not been very active in the field of adult education. I believe the time is not far distant when the public school will serve as a community center for general adult education. They will have discussion groups, study clubs, forums, music, art, dramatics, crafts, recreation, parent education, consumer education, and in fact all types of work which appear to meet the needs of local people. Add to the programs of the school (including vocational agriculture) and the extension service, those of the parent-teacher association, churches, farm bureau, grange, women's clubs, business men's clubs, library, social agencies, marketing and other organized groups, and you have a problem which calls for group planning and coördination. Since the extension agent works with and through many of these agencies he is in a most favorable position to assist with the planning and coordination.

2. Extension workers can frequently enlarge the possibilities of their program by reaching important groups indirectly through other agencies. For example, it is difficult to get poultry farmers to follow the practices necessary to produce eggs of high quality if they are unable to find a market which will pay for this quality. In comparatively few of our urban centers do the consumers appreciate the meaning of quality in eggs to the degree that they will insist upon buying on the basis of state or federal grades. A great deal of consumer education is needed in this field. The following will illustrate what can be done by working through a commercial agency. Last year the Fisher Company of Cleveland agreed to handle government-graded eggs in their 300 retail stores. Arrangements were made by the marketing division of the Ohio Farm Bureau Federation to supply them with eggs graded according to United States standards. The eggs were delivered fresh to the retail stores under a dating plan. The Fisher Company called upon the poultry extension specialists of Ohio State University to instruct their store managers on how to handle the eggs in the stores in

order to keep them fresh. The store managers were also given instruction on the meaning of quality in eggs so they could talk intelligently on the subject to their customers. This program was accompanied with a publicity campaign through the newspapers and billboards designed to acquaint the consuming public with the importance of quality as a consideration in buying eggs. All of the reports seem to indicate that this venture has been quite successful. Thousands of people have learned to depend upon government grades in order to get eggs of high quality and the growing pressure of consumer demand has made Cleveland a much better egg market.

Here is an example of how poultry extension workers have been able to reach large numbers of consumers with a program of consumer education with a minimum of time by doing it indirectly through a commercial agency. They can also work through other organized groups such as women's clubs and consumer coöperatives which are already giving some attention to consumer education. The problem of consumer education is so vital to the production and marketing of poultry that extension workers cannot ignore it. They certainly do not have sufficient staff at present to attempt to reach large numbers of consumers directly but much can be done by working through other agencies.

3. Extension workers must find some way to reach more of our farm people. This, of course, is an old subject. Ever since I have had any contact with extension I have heard the workers discussing whether they should attempt to limit their efforts to the upper third or the upper half or try to reach all of the farm people. In practice we have been reaching the more capable farmers because they are the most easily reached through informal methods of education. We have assumed that if we could get a few farmers in each county to adopt modern farming methods, what they do would serve as demonstrations from which their neighbors would learn. Studies have shown that thousands of people have been reached indirectly by this method but it has its limitations. A man might very well adopt certain farming practices used by his neighbor without anything very significant happening to his own thinking. If extension work is to be worthy of the name education it must be concerned with the educational growth of the individual. For a farmer to adopt a new practice regardless of where he gets the idea is the beginning of the learning process but it should not stop there. He should be led through a process of thinking which helps him to understand more clearly the meaning of what he is doing. Unless this is done the permanent educational value of the experience is very limited.

A good illustration of what I mean is being carried on in the extension poultry schools. The chief weakness of this program is that a small staff can reach so few people and they probably will not be reaching the ones who need it most. I realize that teachers of agriculture and other adult leaders are now helping in this program. I believe that poultry specialists can well afford to devote more time in preparing source materials for use by these people and in giving them specific training. Unless extension workers do furnish a guiding hand in developing a program which reaches more farm people, other adult education agencies may come in and provide a substitute program. This may have a tendency to weaken the future possible developments of the extension program.

4. Extension workers should devote more attention to the young adult group on the farm to see if their interests and needs are being met. I do not have in mind any figures on the age distribution of poultry co-

operators but I have the impression that the majority are above 30 years of age. In Ohio it was found that less than 20 percent of the students enrolled in poultry schools were below 30.[3]

This is a serious problem because the period between the age limits of 18 and 30 is the one in which those young men who expect to farm are going through the process of establishing themselves in farming. A recent study of the time required for a large number of farmers to become well established in farming shows that it took the average farmer nine years from the time he graduated from high school until he became a farm operator either as owner or tenant. This nine-year period has important educational significance. Usually it means that the young man is left at this most critical time with little educational guidance and help. The public school drops him at 18. Some of these young people are being reached by the teachers of vocational agriculture through young men's farming clubs and others are being reached through extension projects. The majority are not being given adequate attention at present.

I believe that the public schools hold a key position in this matter. Suppose for example that before each student leaves high school he would be taught the importance of identifying himself with some program in adult education which will keep him growing. I am thinking here of those who do not go directly to college. If this were done it would make the problem of reaching people much simpler and would place adult education in its proper relation to the school.

5. After emphasizing so strongly the need for close coöperation among adult education agencies in planning their programs, perhaps we should remind ourselves that this same philosophy applies equally well to the activities within our own group. Does the specialist go out to promote his own projects independent of the rest of the extension program or does he see his program in relation to the total program of education for the farmer, his family, and the community? Is the specialist familiar with the objectives of each of the other specialists so that one may assist in strengthening the work of the other? Do our college teachers think of a student's education beginning when he enters college and ending when he graduates? If so, the student will have little understanding of the agencies for adult education and will be poorly prepared to participate in them. Do the research workers in our experiment stations know about the baffling problems which our extension workers find difficult in solving because of insufficient scientific data? Are their researches moving in the direction which will yield data most helpful to the extension worker? The answers to these questions are obvious. The problem is largely one of the right kind of working relationships.

[3] Ferguson, C. M. Paper presented at annual meeting of Poultry Science Association, 1933.

May I summarize briefly what I have tried to say:

1. For the first time in this country there are evidences of a general adult education movement which already has reached considerable magnitude and scope.

2. As agencies engaged in adult education expand they must work more closely together in planning their programs in order that one will strengthen the work of the other and also to avoid overlapping and conflict.

3. Extension workers can enlarge the possibilities of their program by:

a. Reaching important groups indirectly through other agencies.

b. By finding new ways of reaching farm people who are not being reached at present.

c. By giving increased attention to the young farmer group.

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4. Provision should be made for the closest working relationships of college, extension, and experiment station staffs.

If extension workers are to be educators in the largest sense they must of course be scholars in their respective fields. But this is not enough. They must understand the significance of the adult education movement and be reasonably familiar with the purposes and programs of agencies in adult education. But still this is not enough. They must be skilled teachers of adults, who are trying to find meaning in their everyday experiences.

They do not live in cloistered halls on a high hill but direct their teaching toward the solution of the everyday problems of rural adult people in order that these people may live more richly and more abundantly.

They do not belong to the realm of the academic mind which is so frequently characterized by the following bit of philosophy.[4]

Greeting his pupils, the master asked:

What would you learn of me? and the reply came:

How shall we care for our bodies?

How shall we rear our children?

How shall we work together?

How shall we live with our fellowmen?

How shall we play?

For what ends shall we live? . . .

And the teacher pondered these words, and sorrow was in his heart, for his own learning touched not these things.

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[4] Chapman, J. C., Counts, G. S. Principles of Education. Houghton-Mifflin, Boston, 1924.

Infectious Laryngotracheitis

F. R. Beaudette
New Jersey Agricultural Experiment Station,
New Brunswick, New Jersey

(Presented at Annual Meeting†, August, 1936; received for publication August 22, 1936)

INFECTIOUS laryngotracheitis is said to be the correct name for the disease rather than infectious bronchitis. The proper name infers that the disease process is a descending one but, long as the name is, it is still not sufficiently inclusive. It is insufficient for the reason that there are cases in which the nasal cavity and sinuses or the eyes are affected without involvement of the larynx or trachea. This point is mentioned because while most everyone recognizes the usual symptoms the atypical cases are frequently mistaken for some other infection. Thus, while the disease is often easily diagnosed the occurrence of atypical cases at once makes it necessary to differentiate the infection from coryza, pox infection of the eye or mouth, localized cholera, and streptococcus infections and vitamin A deficiency. Moreover, the gasping symptom ordinarily accepted as typical of the disease is also a prominent symptom in infectious bronchitis (gasping disease, chick bronchitis), New Castle disease, Gapeworm infestation, tracheitis of quail, and sometimes in air sac mite infestation of the trachea, pullorum disease and aspergillosis of chicks and even in fowl paralysis when the vagus nerve is involved. Therefore, a correct diagnosis of a respiratory disease is frequently impossible until autopsy, bacteriological examinations, animal inoculations, and cross immunity studies have been made. Further elaboration on these points would require more space than is permitted.

At first the disease was known in the United States and Canada but it is now known to occur in Germany, England, Hawaii, and Australia. Outbreaks are more frequent in the fall and the losses greatest in colder months in birds under heavy production. However young chicks may be attacked during the warmer months.

Thus far the chicken and the pheasant or hybrids of these are the only known susceptible species.

The cause of the disease is a virus which is filterable through Berkefeld V and N filters and occasionally through Seitz discs.

The virus can be grown in a medium of minced chick embryo and Tyrode's solution, but propagation on the chorio-allantoic membrane of the developing chick embryo affords an ideal means of study. By this method the virus can be cultivated in the absence of bacteria and will retain its disease-producing properties apparently after innumerable passages.

Chickens acquire the disease when the virus is placed in the eye, nasal cavity, sinus or respiratory tract. Since subcutaneous, intramuscular and usually intravenous inoculations are without effect one need not look for an insect vector. Moreover, since the virus is confined almost exclusively to the respiratory tract blood-sucking parasites have no opportunity to become infected.

Certain survivors of infection continue to carry the virus in the respiratory tract and are a hazard to any susceptible bird with which they come in contact. The disease is largely transferred from one place to an-

* Journal Series paper of the N. J. Agricultural Experiment Station, department of poultry husbandry.

† Presented as a review at the sectional conference dealing with avian pathology.

other through the medium of carrier birds. *However, the virus might be carried mechanically* on the clothing, used feed bags, soiled crates, and other equipment. After the disease is once introduced on a premise it is carried over from year to year in carriers. During these annual outbreaks on a farm the old birds escape infection because the attack which they had in early life conferred a permanent immunity. The disposal of all old birds and disinfection of the premises sometime before the chicks are hatched has been recommended as a means of eliminating the infection, but this gives no assurance that the owner will not again permit the disease to be brought in by the same agency that started the first outbreak.

It has already been mentioned that an attack of the disease confers a permanent immunity. Since death is due entirely to suffocation, the disease process set up artificially in the cloaca by inoculation is harmless, and provokes an immunity as lasting as that following the natural disease. Hence, this method of immunization is now commonly practiced on many farms where the disease has taken its toll in the past. The method is also of value during an outbreak (emergency vaccination) because prompt vaccination *of non-affected units prevents* further spread of the disease. In rare cases susceptible birds may be vaccinated to protect them when they are to be placed with known survivors of an outbreak, but traffic in live birds is always to be discouraged. Otherwise non-infected farms might be vaccinated only when established in known infected poultry colonies, that is, where a wire fence is the only separation between poultry runs or ranges.

The success of vaccination depends entirely upon the use of a highly potent vaccine and the observance of proper directions for application. Here is must be stated that we are dealing only with the specific virus vaccine. The so-called mixed infection bacterins will not prevent or cure any known *poultry disease. A potent vaccine is one* that will produce at least 95 percent readable "takes" in susceptible birds, and with this percentage the remaining 5 percent are very likely to be immunized whether the reaction was readable or not. If a vaccine produces a low percentage of "takes" only those birds will be immunized and the remaining ones usually contract the infection eliminated by the birds with "takes." In this event symptoms and losses begin about the tenth or eleventh day and are in proportion to the number of "no takes." If vaccination is properly done there should be no systemic disturbance and no loss. Consequently, birds may be vaccinated at any time after the age of six weeks. However, since pox vaccine is invariably applied at the same handling vaccination should be done before the birds are three months old. In this event there will of course be the usual reaction to the pox vaccine.

The question is frequently raised as to whether vaccination will not further disseminate the infection. As long as vaccination is confined to infected farms the practice will not spread the disease but will tend to prevent spread. A farm once infected suffers *an annual outbreak through* the medium of carriers and in the past poultrymen have usually had no scruples against the selling of stock containing carriers from such farms, which accounts for the present prevalence of the disease. Curiously enough the virus does not persist in the cloaca of vaccinated birds after the reaction subsides as it often does in the trachea following a natural attack. Hence, vaccination of young stock on an infected farm enables the owner to make sales (if he must) to a non-infected farm without fear of transmitting this disease at least. It is also to be remembered that whereas vaccinated birds are infectious only for about 10 days, the same birds allowed to have the disease naturally, permits

the production of carriers that are infectious for months and sometimes for life. Finally, vaccination enables a poultryman to vaccinate his flock in an emergency to prevent further spread of the infection whereas otherwise he might do what has already been done too often, namely, cull out the visibly affected birds and sell the apparently healthy ones at a sacrifice to some unsuspecting poultryman or to the feeder. The terrible losses sustained in feeding stations is largely due to this infection and is part of the answer to the low price paid for meat. Vaccination would make it possible for the original owner to keep his birds and realize a profit on them by continued production. However, it should be pointed out that vaccination is specific and will not protect chickens against the various diseases that look like laryngotracheitis. Therefore, an accurate diagnosis should be made before vaccination is attempted.

Vitamin D Requirements of Growing Chicks as Affected by the Calcium Content of the Ration

J. R. Couch, G. S. Fraps, and R. M. Sherwood
Texas Agricultural Experiment Station, College Station, Texas

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THE vitamin D requirements of chickens has been a subject of investigation since the work of Bethke, Record, and Kennard (1) who concluded that the chick required for normal calcification 18.9 International units of vitamin D from cod liver oil per 100 grams of ration. Murphy, Hunter, and Knandel (4) reported that the chick required a minimum of 17 International units of vitamin D from cod liver oil per 100 grams of ration from hatching time till 24 weeks of age. Carver, Robertson, Brazie, Johnson, and St. John (2) found that the chick required 17 International units of vitamin D from cod liver oil per 100 grams of ration for satisfactory calcification and growth. Russell, Taylor, and Wilcox (5) reported that normal bone ash and body weight were obtained in chickens at eight weeks of age when 14.9 International units of vitamin D from cod liver oil per 100 grams of ration were fed. The calcium and phosphorus content of the rations used by these investigators (1, 2, 4, and 5) varied rather widely. Couch, Fraps, and Sherwood (3) concluded that the number of units of vitamin D required by growing chickens appeared to depend upon the nature of the ration, especially the percentages of calcium and phosphorus contained in it, and that the vitamin D requirements of chickens varied with the particular factor taken into consideration in deciding upon the effect of the vitamin D supplied. They found that chickens fed a ration containing 1.48 percent calcium and 0.65 percent phosphorus required 12.3 International units of vitamin D from cod liver oil per 100 grams of feed for maximum growth and best utilization of the feed, and 3.1 International units of vitamin D from cod liver oil per 100 grams of feed for the prevention of rickets and crooked breast bones and calcification of the bones at 12 weeks. They found that when a ration containing 0.96 per cent calcium and 0.66 percent phosphorus was fed, the chickens required 50.2 International units of vitamin D from cod liver oil per 100 grams of ration. This high vitamin D requirement was attributed to the low calcium content of the ration. The work herein reported is a continuation of the work of Couch, Fraps, and Sherwood (3).

EXPERIMENTAL

The White Leghorn chicks used in this study were from stock maintained at the Poultry Division of the Texas Station. The hens from which these chicks were hatched were running on free range in sunlight and adequate green feed was available at all times. The chicks were hatched in a forced draft incubator, were kept in a battery brooder room from which all outside sunlight was excluded, and were allowed a 14-hour feeding period each day. Feed was weighed to the chicks daily and fresh tap water was available at all times.

Two series of rations were fed to duplicate groups of chicks in two experiments for

TABLE 1.—*Relation of vitamin D and calcium to gain in weight, rickets, and other criteria on chickens fed ration 1, experiment 1*

Percent calcium in ration	1.31			1.50	
International units of vitamin D per 100 grams ration	1.1	1.9	2.6	1.1	1.9
Mean gain of cockerels	640.9±23.0	782.9±21.8	844.5±16.0	735.8±18.4	862.6±18.0
Mean gain of pullets	512.2±15.5	588.1±19.0	722.6±17.9	634.3±14.6	710.0±16.0
Grams of feed required to produce one gram of gain	4.61	4.17	3.98	4.44	3.95
Mean percentage of bone ash	40.16	43.54	45.00	42.01	44.31
Percent of chicks that had crooked breast bones	58.3	27.1	4.2	14.9	2.0
Percent of chicks that had rickets	68.8	25.0	4.2	25.5	2.0
Number chicks that died during experiment	3	4	4	5	2

12 weeks. The basal ration used in the first experiment was composed of 6 percent meat and bone scraps, 6 percent cottonseed meal, 6 percent dried buttermilk, 3 percent dehydrated alfalfa leaf meal, 20 percent wheat gray shorts, 1 percent salt, and 58 percent ground yellow corn. The basal ration used in the second experiment was made up of the same ingredients as the first ration except that 10 percent wheat gray shorts was substituted for a like amount of ground yellow corn, making a total of 30 percent wheat shorts. In the first experiment using the first ration, 1.1, 1.9, and 2.6 International units of vitamin D were fed with 1.31 percent calcium, and 1.1 and 1.9 International units of vitamin D were fed with 1.50 percent calcium. In the second experiment using the second ration 1.2, 2.4, and 3.6 International units of vitamin D were fed with 1.51 and 1.71 percent calcium. The vitamin D was supplied by a cod liver oil which contained 26.7 International units of vitamin D per gram. In varying the calcium content of the rations, oyster shell replaced an equal amount of ground yellow corn. The percentages of oyster shell used with the first ration were 1 and 1.5 percent and with the second ration were 1.5 and 2 percent. The phosphorus content of the first and second rations was 0.76 and 0.81 percent respectively.

RESULTS AND DISCUSSION

Chickens fed rations containing 1.1, 1.9, and 2.6 International units of vitamin D per 100 grams of ration in one experiment (Table 1) and 1.2, 2.4, and 3.6 Interna-

TABLE 2.—*Relation of vitamin D and calcium to gain in weight, rickets, and other criteric on chickens fed ration 2, experiment 2*

Percent calcium in ration	1.51			1.71		
International units of vitamin D per 100 grams ration	1.2	2.4	3.6	1.2	2.4	3.6
Mean gain of cockerels	713.5±11.5	818.8±14.0	898.2±18.1	716.1±16.2	788.1±20.4	908.7±13.9
Mean gain of pullets	642.6±17.1	610.0±16.9	759.2±16.3	599.1±16.1	732.5±10.8	726.0± 9.1
Grams of feed required to produce one gram of gain	4.10	3.95	3.67	4.19	3.84	3.82
Mean percentage of bone ash	41.55	43.95	47.05	42.63	45.61	46.53
Percent of chicks that had crooked breast bones	37.5	7.0	0	20.8	0	0
Percent of chicks that had rickets	35.7	14.0	0	10.4	0	0
Number of chicks that died during experiment	7	7	8	16	13	7

tional units of vitamin D per 100 grams of ration in another experiment (Table 2) gave better results as the vitamin D was increased up to the highest level fed, though the calcium varied from 1.31 to 1.71 percent in the two experiments. The mean gain of both cockerels and pullets increased, the grams of feed required to produce one gram of gain decreased, the mean percentage bone ash increased and the percentage of chicks with rickets and crooked breast bones decreased with increasing amounts of vitamin D up to the highest amount fed regardless of the calcium content of the ration (Tables 1 and 2).

The vitamin D requirements of the chicks decreased as the calcium content of the ration was increased up to 1.71 percent calcium. In the first experiment (Table 1) the results were approximately the same for the group receiving 1.1 units of vitamin D per 100 grams of ration with 1.50 percent calcium as the results of the group receiving 1.9 units of vitamin D per 100 grams of ration with 1.31 percent calcium; the results were approximately the same for the group *receiving 1.9 units of vitamin D per 100* grams of ration with 1.5 percent calcium as the results of the group receiving 2.6 units of vitamin D per 100 grams of ration with 1.31 percent calcium. In the first experiment (Table 1) when the groups receiving the same levels of vitamin D are compared, the higher level of calcium (1.5 percent) produced significantly higher gains in both cockerels and pullets, and required less feed to produce a gram of gain than the lower level of calcium (1.31 percent). In the second experiment (Table 2) there was very little difference in the gains of the chicks and the grams of feed required to produce a gram of gain when groups receiving the same levels of vitamin D are compared. In both the first and second experiments (Tables 1 and 2) the mean percentage of bone ash increased and the percentage of rickets and crooked breast bones decreased with the higher levels of calcium, 1.5 percent in the first experiment and 1.71 percent in the second experiment, though the levels of vitamin D of the groups compared, remained constant.

SUMMARY

1. With the low levels of vitamin D used in this study, and with suitable percentages of calcium and phosphorus, the quantity of the vitamin required depends upon the quantity of calcium present.

2. The small quantity of 3.6 International units of vitamin D per 100 grams of ration when fed with a ration containing 1.51-1.71 percent calcium appeared satisfactory for the first 12 weeks for growth and calcification of the bones in chickens kept in the absence of sunlight.

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Constituents of Wheat Gray Shorts Which Prevent Slipped Tendons

R. M. Sherwood and G. S. Fraps
Texas Experiment Station, College Station, Texas

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During recent years a number of workers, including Titus and Ginn (17), Titus (16), Hunter and associates (8), Graham and associates (3), Branion (1), and Sherwood and Couch (14) have found that certain feeds protected chicks reasonably well against slipped tendons or perosis especially when the mineral levels were satisfactory.

Workers including Wilgus and associates (19), Milby (10, 11), Hammond (14), Insko and associates (9), Payne and associates (12), Buckner and associates (2), Herner and Robinson (7), Heller and associates (5, 6), and Sherwood (13) studied the effects of minerals on the occurrence of slipped tendons or perosis. Hammond (4) stated that organic phosphorus prevented this condition while inorganic phosphorus caused the trouble.

Workers including Graham and associates (3), Titus (16), and Sherwood and Fraps (15) have tried to isolate and identify the material in the feeds studied which prevents slipped tendons or perosis. These workers tried to isolate some organic material, possibly a vitamin which would account for the corrective action of the feeds studied. Graham and associates (3) made an attempt to isolate the factor influencing rate of growth, rate of feather growth, and perosis. They reported that a part of the activity of wheat germ middlings may be removed in solvents of a slightly acid nature. Titus (16) suggested that the corrective factor might be one of the vitamin B complex but could not be a fat soluble vitamin as it was not soluble in ether.

Sherwood and Fraps (15) did not succeed in isolating measurable quantities of the slipped tendon preventing factor with any of their extractions of wheat gray shorts. The work herein reported is a continuation of these studies.

EXPERIMENTAL

The chicks used in this study and the methods of incubation, brooding, and feedings were as nearly uniform as possible.

Two different experiments were conducted on this project during the spring of 1936, using a total of about 450 chicks. The use of a large extracting apparatus permitted the preparation of extracts of about 80 pounds of wheat gray shorts and the use of correspondingly large numbers of chickens. The diets used are given in Table 1. The basal diet, diet 1, was known to produce a high percentage of slipped tendons.

In making the extracts of wheat gray shorts the ethylene dichloride extract was first made and the residue was then extracted with 90 percent alcohol. Each of these extracts from 20 pounds of wheat gray shorts were dried and mixed with enough ground kafir to make up two 20-pound portions. These were incorporated in the feed in place of the 20 percent of ground kafir used in diet 1 to make diets 2 and 3. The residue remaining after 20 pounds of wheat gray shorts had been extracted with ethylene dichloride and alcohol as well as the ash from another 20-pound portion of wheat gray shorts were each mixed with enough ground kafir to make up 20-pound

TABLE 1.—*Ingredients of chick diets in percent*

	Diet numbers					
	1	2	3	4	5	6
Wheat gray shorts	0	0	0	0	0	20
Ground kafir	20	—	—	—	—	—
Ground kafir plus ethylene dichloride extract of 20 lbs. of wheat gray shorts	—	20	—	—	—	—
Ground kafir plus alcohol extract of 20 lbs. of wheat gray shorts	—	—	20	—	—	—
Ground kafir plus residue of extraction of 20 lbs. of wheat gray shorts by ethylene dichloride and alcohol	—	—	—	20	—	—
Ground kafir plus ash of 20 lbs. of wheat gray shorts	—	—	—	—	20	—
Ground yellow corn	56.87	56.87	56.87	56.87	56.87	56.87
Meat and bone scraps	9	9	9	9	9	9
Dried skimmed milk	9	9	9	9	9	9
Dehydrated alfalfa leaf meal	3	3	3	3	3	3
Chick size oyster shell	1	1	1	1	1	1
Salt	1	1	1	1	1	1
Fortified cod liver oil	.13	.13	.13	.13	.13	.13

portions and were used in place of the 20 percent of ground kafir as used in diet 1 to make up diets 4 and 5. In diet 6, 20 pounds of wheat gray shorts was used in place of the 20 percent of ground kafir as used in diet 1. The shorts used for the extractions and ash was the same as that used in diet 6.

These chicks were fed for a period of 12 weeks with a feeding period of 14 hours per day. The slipped tendon observations as reported were taken at the end of the experiment and the slipped tendon indexes were figured from these data. The slipped tendon index is similar to the perosis value of Titus and Hammond (18) except that it is 100 times as large. The index is figured by giving each chick a value of 0, 1, 2, or 3 to correspond with no slipped tendons, a slight case, a medium case, or a bad case. These values are summated and divided by three times the number of chicks and their quotient is multiplied by 100. The more severe the trouble the higher is the index.

Table 2 gives the observations on slipped tendons and the slipped tendon index for chicks on the different diets. The basal diet alone, the ethylene dichloride extract of wheat gray shorts, diet 2, and the alcohol extract of wheat gray shorts, diet 3, produced practically the same rather high slipped tendon index. The basal diet with the addition of the residue from the extraction of the wheat gray shorts with ethylene dichloride and alcohol, diet 4, basal

TABLE 2.—*Summary table on slipped tendons or perosis and slipped tendon index for the various separations*

	Number of chicks	Number with			
		Slight slipped tendon	Medium slipped tendon	Bad slipped tendon	Slipped tendon index
Diet 1—Basal ration	58	13	12	8	35.1
Diet 2—Ethylene dichloride extract of wheat gray shorts	52	11	16	7	41.0
Diet 3—Alcohol extract of wheat gray shorts	60	17	10	11	38.9
Diet 4—Residue from the extraction with ethylene dichloride and alcohol	66	5	3	1	7.1
Diet 5—Ash of wheat gray shorts	57	5	2	1	7.0
Diet 6—Wheat gray shorts	64	1	1	2	4.7

diet with the addition of the ash of wheat gray shorts, diet 5, and wheat gray shorts, diet 6, produced practically the same low slipped tendon index. The fact that a large number of chicks were used in these experiments and that both experiments gave corresponding results make this data significant. They show that the factor in wheat gray shorts which prevents slipped tendons or perosis is not an organic substance, as has been concluded from some previous experiments with other feeds, but is one or more of the mineral constituents of the ash.

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Dressing Shrinkages of Bronze Turkeys

Stanley J. Marsden

Bureau of Animal Industry, United States Department of Agriculture, Washington, D.C.

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DRESSING percentages of food animals are of considerable economic importance to the producers, distributors, and consumers of them. This paper is a compilation of original data relating to the determination of weight losses sustained by turkeys during their preparation for cooking. The data were obtained from more than twelve hundred birds of the Bronze variety. The birds were raised and prepared for market on the U. S. Range Livestock Experiment Station at Miles City, Montana, during the years of 1929, 1930, 1931 and 1932.

The turkeys used in this study were reared on limited range with access to feed at all times from hatching to marketing. The young birds were slaughtered, in the great majority of cases, between the ages of 26 and 32 weeks, during November and December. A few were slaughtered at 22 to 26 weeks of age, during November and December. A few were held as long as 10 or 11 months, and slaughtered during January, February and early March.

All birds were subjected to an overnight period of fasting by closing or removing the feeders after the birds had gone to roost on the evening prior to slaughter. Water but no feed was permitted on the day of slaughter. The turkeys were suspended by the legs and bled by reaching into the mouth and severing the jugular veins at the rear of the throat. The feathers were then loosened by puncturing the posterior lobe (or medulla) of the brain and dry-picked in the usual manner after which the mouth was freed of any accumulated blood and the area under the vent squeezed to remove any dropping present in the cloaca. Chilling was accomplished by allowing the carcasses to hang by both legs over night in a room temperature ranging from about 25° to 45° F.

Data relating to fleshing grade, shape of keel, weight just before killing, and the cooled weight after the carcasses had been chilled overnight were obtained in all cases. In some cases the following additional information was obtained: live weight just prior to the start of the fasting, dressed weight after picking (allowing sufficient time for the blood to drain completely from the carcass) and weight of the full-drawn carcass with edible giblets restored.

Carcass grading was based on fat and fleshing, no consideration being given to picking defects, blemishes, pin feathers, or shape of breastbone. Data from birds that were emaciated, not properly starved, hunchbacked, or possessed of pendulous crops were not included. Based only on fleshing and covering of fat, the four grades used are described as follows:

Special (or No. 1-A): Breast broad and well fleshed; entire carcass fully covered with fat.

Prime (or No. 1): Breast well fleshed; entire carcass well covered with fat.

Choice (or Medium): Breast fairly well fleshed; entire carcass fairly well covered with fat.

Commercial (or No. 2): Carcass poorly fleshed and poorly covered with fat. Emaciated birds were considered as undergrade and were not classified.

These descriptions correspond to those of the U. S. Grading plan sponsored by the Bureau of Agricultural Economics.

RESULTS

The data obtained from this study are presented in the following tables:

breasted toms lose to the same extent as crooked-breasted toms; yearling and two-year-old turkeys, both males and females,

TABLE 1.—*Weight loss during overnight fasting (1930, 1931, 1932).*

Class of turkeys	Number of birds	Average live weight before fasting	Weight loss during fasting
		pounds	percentage
Young males	155	18.55	3.33
Young females	85	11.46	3.32
Yearling and two-year-old females	31	13.67	3.49
Totals and weighted averages	271	15.77	3.34

It was demonstrated in this and other work that overnight fasting is sufficient to properly prepare turkeys for slaughter provided ground feed only is given on the day prior to slaughter when turkeys are allowed to eat their fill up to sundown. When slaughtering continues until late in the evening the following day, the turkeys will have fasted approximately 12 to 28 hours. In order to be certain that feed has passed from the crops of the birds slaughtered in the morning it is necessary to feed only ground feed, preferably ground grain without protein supplements. If whole or cracked grains are fed, the fasting must be extended to a minimum period of about 24 hours. It appears preferable, however, to use the overnight fasting plan for two reasons: (1) to prevent unnecessary loss of weight and (2) to minimize the danger of the birds' eating litter, droppings, feathers, or soil, thus defeating the purpose of the fasting. The results show that the weight loss during overnight fasting is a highly significant factor in the marketing of turkeys.

A study of tables 2, 3, and 4, reveals several significant facts. The percentage weight loss of young toms during slaughtering, dry-picking, and chilling is practically the same as it is for young hens. Large birds lose a smaller percentage than small birds; fat birds lose less than thin birds; straight-slaughtered in the fall, lose slightly, but probably not significantly, higher percentages than do young birds of similar weight; yearling and two-year-old hens slaughtered in the spring loss significantly less weight than birds of the same age and sex slaughtered in the fall.

The weight loss due to overnight air-cooling was insignificant, averaging .23 percent for young males and females. In a previous report (1931), the author found a loss of approximately .33 percent during overnight chilling and Alder (1936) found a loss of approximately .75 percent during a 24-hour chilling period and about 1.10 percent in 48 hours. However, it was noted during the collection of the present data that when the birds were allowed to hang by the feet for about 2 hours until all blood had drained away, then properly "squeezed," and relieved of blood clots in the mouth and throat, before the post-dressing weights were taken, the weight loss during chilling was insignificant as reported in Table 3. When they were weighed as soon as picking was completed, a much greater apparent chilling loss was obtained but this was due to the slow dripping of blood for an hour or two after picking or in some instances to removal of droppings or blood clots in the mouth after the fresh-dressed weights were taken.

Percentage weight loss due to slaughter-

TABLE 2.—*Weight loss of young turkeys during slaughtering, dry-picking, and overnight chilling (1929, 1930, 1931, 1932).*

Grade based on fat and fleshing		Live weight classification in pounds at time of slaughter (after fasting)											
		Males					Females					Males and females	
												All weights	
		Under 16.00	16.00–19.95	20.00–23.95	24.00 and up	All males	Under 8.00	8.00–10.95	11.00–13.95	14.00 and up	All females	Totals	Weighted averages
Special	No. of birds	8	104	82	42	236	0	85	186	25	296	532	
	Mean live weight	15.44	18.42	21.53	26.80	20.89	—	10.28	12.23	14.58	11.87		15.87
	Percentage weight loss	9.85	9.64	9.26	8.50	9.25	—	9.83	9.20	8.62	9.30		9.27
Prime	No. of birds	114	211	23	0	348	0	114	44	0	158	506	
	Mean live weight	14.66	17.64	20.95	—	16.88	—	9.80	11.62	—	10.30		14.83
	Percentage weight loss	10.04	9.88	9.37	—	9.88	—	10.14	9.51	—	9.94		9.90
Choice	No. of birds	103	18	0	0	121	0	34	0	0	34	155	
	Mean live weight	13.46	16.98	—	—	13.99	—	9.17	—	—	9.17		12.93
	Percentage weight loss	9.87	9.72	—	—	9.84	—	9.80	—	—	9.80		9.83
Special, Prime, and Choice combined	No. of birds	225	333	105	42	705	0	233	230	25	488	1,193	
	Mean live weight	14.14	17.85	21.41	26.80	17.73	—	9.88	12.11	14.58	11.17		15.05
	Percentage weight loss	9.96	9.79	9.28	8.50	9.63	—	9.98	9.26	8.62	9.54		9.60
Commercial	No. of birds	38	0	0	0	38	7	5	0	0	12	50	
	Mean live weight	12.36	—	—	—	12.36	7.49	8.61	—	—	7.96		11.30
	Percentage weight loss	10.23	—	—	—	10.23	10.01	10.57	—	—	10.26		10.24
All four grades, totals and weighted averages	No. of birds	263	333	105	42	743	7	238	230	25	500	1,243	
	Mean live weight	13.88	17.85	21.41	26.80	17.45	7.49	9.85	12.11	14.58	11.10		14.90
	Percentage weight loss	9.99	9.79	9.28	8.50	9.65	10.01	9.99	9.26	8.62	9.55		9.62

TABLE 3.—*Weight loss of young and adult turkeys during slaughtering, dry-picking, and overnight chilling (1929–30).*

Classification	Number of birds	Mean live weight in lbs. at time of slaughter (after fasting)	Percentage weight loss
Weight loss during dry-picking of adult turkeys			
Yearling and two-year-old females slaughtered in June (Prime and Choice grades).	48	13.20	6.70
Yearling females slaughtered in Nov.–Dec., 1930 (Prime and Special grades).	81	13.35	9.80
Yearling males slaughtered in Nov.–Dec., 1930 (Prime and Special grades).	16	28.71	8.82
Weight loss during dry-picking of straight and crooked-breasted young turkey toms.			
Special, Prime and Choice birds with straight, slightly to moderately dented, and curved (slightly crooked) breastbones	236	17.94	9.54
Special, Prime and Choice birds with decidedly crooked breastbones	67	16.84	9.41
Weight loss of young turkeys during overnight chilling.			
Special, Prime and Choice males	354	16.71*	.22**
Special, Prime and Choice females	107	10.03*	.27**
Totals and weighted averages for both sexes	461	15.16*	.23**

* Mean dressed weight before chilling.
** Percentage weight loss due to chilling.

ing, dry-picking, and chilling (dressing shrink) was similar to that obtained by Barton (1928), Marsden (1931), and the Purdue Agricultural Experiment Station (1933) but on the average was lower for both sexes than that reported by Alder (1936). Figures reported by Funk and Margolf (1932) were the same for males, but about 1 percent higher for females, when groups in the same weight class were compared.

The percentages of weight loss due to full-drawing as reported in this paper are similar to those reported by Barton (1928) and by the Purdue Agricultural Experiment Station (1933) but are approximately 1 percent lower than those of Funk and Margolf (1932). There was no significant difference in weight loss due to full-drawing between straight-breasted and crooked-breasted toms but large birds of both sexes lost significantly less than the smaller birds and toms lost approximately 0.7 percent less than hens.

SUMMARY

The weight loss of 271 Bronze turkeys of both sexes during overnight fasting averaged 3.34 percent of the live weight before fasting. There were no significant differences due to age or sex.

The weight loss of 1,243 young Bronze turkeys of both sexes and all weights and grades during the slaughtering, dry-picking, and overnight air-chilling (dressing shrinkage) averaged 9.62 percent of the live weight after fasting. Males averaged 9.65 percent, females 9.55 percent. Large birds lost a smaller percentage than small birds;

TABLE 4.—*Weight loss of young turkeys during slaughtering, dry-picking, overnight chilling, and full-drawing.*

Classification	Number of birds	Mean live weight before picking	Mean dressed weight after chilling	Percentage weight loss due to dry-picking and chilling	Percentage weight loss due to full-drawing (L)*	Percentage weight loss due to full-drawing (D)*	Percentage weight loss due to dry-picking, chilling and drawing (L)*
Special and Prime grades	number	pounds	pounds	percent	percent	percent	percent
Toms under 20 pounds** with straight or only slightly deformed breastbones	13	15.90	14.28	10.19	13.24	14.75	23.43
Toms 20 pounds and over with straight or only slightly deformed breastbones	4	21.36	19.32	9.57	12.79	14.15	22.36
Toms under 20 pounds with severely crooked breastbones	13	17.05	15.35	9.99	13.33	14.81	23.32
Toms 20 pounds and over with severly crooked breastbones	2	20.15	18.15	9.93	12.98	14.41	22.90
All Special and Prime young toms	32	17.31	15.58	10.00	13.19	14.65	23.18
Hens under 11 pounds with straight or only slightly deformed breastbones	19	9.82	8.86	9.79	15.14	16.78	24.93
Hens 11 pounds and over with straight or only slightly deformed breastbones	11	13.09	11.91	8.99	12.57	13.81	21.56
Hens 11 pounds and over with severely crooked breastbones	3	11.90	10.65	10.50	13.03	14.55	23.53
All Special and Prime hens	33	11.10	10.04	9.54	13.92	15.39	23.47
All Special and Prime hens and toms	65	14.16	12.77	9.81	13.48	14.95	23.30
Miscellaneous							
Choice and Commercial young toms with straight or only slightly deformed breastbones	5	13.38	12.06	9.87	15.47	17.16	25.34
Choice and Commercial young hens with severely crooked breastbones	2	7.93	7.10	10.41	15.71	17.54	26.12
Very large young toms with straight or only slightly deformed breastbones	2	33.28	30.70	7.74	11.07	12.00	18.81
Large young toms with straight or only slightly deformed breastbones	10	27.08	24.86	8.19	13.25	14.43	21.44

* D indicates percentage based on dressed weight after chilling; L indicates percentage based on live weight after fasting.
** Live weight after fasting.

fat birds lost a smaller percentage than thin birds; toms with straight or only slightly deformed breastbones lost to the same extent as crooked-breasted toms.

The weight loss due to overnight air-chilling was very small, averaging .23 percent of the fresh-dressed weight of 461 young Bronze turkeys. The difference due to sex did not appear to be significant.

Weight loss due to full-drawing averaged 14.65 percent of the dressed and chilled weight of 32 fat young Bronze toms and 15.39 percent of the dressed and chilled weight of 33 fat young Bronze hens. The weight loss due to killing, dry-picking, chilling, and full-drawing averaged 23.18 percent for the 32 young toms and 23.47 percent for the 33 young hens. There were no significant differences due to shape of breastbone, but large birds lost a significantly smaller percentage than small birds during the full-drawing process.

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Effect of the Calcium and Phosphorus Content of the Diet of Chickens on Egg Production and Hatchability

HARRY W. TITUS, T. C. BYERLY, N. R. ELLIS
AND R. B. NESTLER

National Agricultural Research Center, Animal Nutrition and Animal Husbandry Divisions, Bureau of Animal Industry, United States Department of Agriculture, Beltsville, Maryland

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ALTHOUGH many phases of the calcium metabolism of the chicken have been studied, very little attention has been given to the effect of the calcium and phosphorus content of the diet of laying pullets and hens on the production and hatchability of eggs. The purpose of this paper is to present data on this phase of the calcium and phosphorus metabolism of the chicken. These data demonstrate the deleterious effect, hitherto unsuspected, of a high level of calcium intake of laying chickens on the ability of their eggs to hatch, and they suggest that in practical poultry husbandry it is very desirable to control the calcium intake of laying chickens.

LITERATURE

Wheeler (1919) made many inorganic analyses of the shells of eggs and of the carcasses of chickens and ducks that had received calcium, magnesium, and strontium from several sources as supplements to their diet. He found that the diets containing the larger proportions of calcium definitely increased egg production. Also, he concluded that although magnesium could not replace calcium in the shell of the egg or the skeleton of the chicken strontium could do so to a considerable extent.

Buckner, Martin, Pierce, and Peter (1922) and Buckner, Martin, and Peter (1923) found that the calcium in calcium carbonate can be utilized for the production of both bone and eggshell whereas the calcium in tri-calcium phosphate can be utilized for the growth of bone but not for the formation of eggshell. In a later investigation of the availability of the calcium in different calcium salts, Buckner, Martin, and Peter (1928) again found that calcium carbonate was a good source of calcium and that calcium lactate was readily utilized but that calcium sulphate and precipitated tri-calcium phosphate were not. Calcium chloride was not consumed in sufficient quantity to permit drawing conclusions. Kennard's (1925) experiments, however, indicate that the bone (essentially tri-calcium phosphate) in meat scrap may supply calcium for the formation of eggshells.

Massengale and Platt (1929) have presented evidence that the calcium in C. P. calcium carbonate is not so readily available as that in limestone or oyster shell and that the physical state of the calcium carbonate influences its utilization. Russell and McDonald (1929) found that the calcium in calcium citrate may be used for the formation of eggshell. According to Hunter, Dutcher, and Knandel (1933) calcium gluconate is more efficiently utilized than calcium carbonate in the production of eggs.

The evidence thus points to the conclu-

sion that those salts of calcium that have acid radicles which require a base for their elimination are not so well utilized as those that have acid radicles which are readily oxidized in the body or which, at least, do not require a base for their excretion.

Buckner and Martin (1920) and Buckner, Martin, and Peter (1923, 1924a, 1925b, 1926) found that restricting the quantity of calcium in the diet of chickens markedly decreases egg production but has no significant effect on the calcium and phosphorus content of the eggs or on the composition of the shells. Although they observed a thinning of the eggshells when the chickens received a calcium-deficient diet, they concluded that shell-less eggs are not caused by a calcium deficiency. Deobald, Lease, and Hart (1936) failed to get shell-less eggs when the quantity of calcium in the diet of chickens was markedly restricted; however, they did get some eggs with very thin shells. Riddle and Hanke (1921) observed in their studies on egg-laying ring doves that thin-shell eggs cannot be attributed to an inadequate supply of calcium in the feed. The available evidence is that the production of shell-less eggs or of eggs with extremely thin shells is probably not the direct result of a deficiency of calcium and that if the laying chicken does not get enough calcium egg production may cease entirely.

Halnan (1925) conducted a series of nitrogen, calcium, and phosphorus balance experiments with White Leghorn pullets and concluded that egg laying is not preceded by a long period of storage of nitrogen or calcium. He found, nevertheless, that there is a small increase in the retention of calcium and phosphorous for a period of two or three weeks just before egg production begins. Common (1932) observed a similar retention of calcium and phosphorus preceding egg production and found that egg laying was correlated with a heavy voiding of phosphorus in the droppings.

Common's (1933, 1936) later studies indicated that the voiding of phosphorus in the droppings is dependent on the quantity of calcium in the diet. If the diet contains an adequate supply of calcium, heavy phosphorus excretion may not accompany egg production. Common concluded that when there is an increase in the elimination of phosphorus, a temporary draft is being made on the skeleton to supply calcium for the eggshell. This conclusion is strengthened by the fact that Common (1934) found a marked rise in the phosphatase content of the blood of pullets when they begin to lay. Further confirmation is furnished by the experiments of Deobald, Lease, and Hart (1936) which indicate that about 10 percent of the calcium stored in the bones may be called on when there is need of calcium for eggshell formation. That the hen may draw on her body to produce eggs is suggested by the experiments of Titus (1928) who observed that hens continued to produce eggs even when the total feed intake was so small that the losses in live weight of some of the birds were more than 20 percent.

During egg production more phosphorus is excreted in the droppings than during non-production, and the quantity is greater than is necessary for the formation of tricalcium phosphate (Russell and McDonald, 1929). According to Knowles, Watkin, and Hendry (1933) and Common (1933), when the diet contains an adequate quantity of calcium carbonate, phosphorus is normally excreted by the non-laying pullet as dicalcium phosphate. In the laying hen, when a heavy excretion of phosphorus accompanies egg laying, a water-soluble form of phosphorus—probably ammonium phosphate—is also excreted (Common, 1933, 1936). Knowles, Watkin, and Hendry (1933) further concluded that in the non-laying pullet any excess of calcium over that

required to form di-calcium phosphate is excreted as calcium carbonate. That this is not at all improbable is indicated by the experiments of Waite (1935) who found that if laying hens consume more oyster shell than they need, the presence of calcium carbonate may be demonstrated in the droppings, and that rather large quantities may be excreted.

Russell, Howard, and Hess (1930) have observed that as the ova reach a certain size the level of calcium in the blood tends to rise. Charles and Hogben (1933) reported wide variations in the blood calcium during the period that the egg is in the oviduct; the range was 10.5 to 28.5 mg. per 100 c.c. of blood. Knowles, Hart, and Halpin (1935) were able to show that there is a direct correlation between the level of calcium in the blood and the position of the egg in the oviduct. Buckner, Martin, and Peter (1924b) concluded from their study of the calcium and phosphorus content of five different sections of the oviduct that the calcium deposited as eggshell is not associated with the phosphorus of the oviduct but comes in another form in the blood to the uterus.

Common (1933) found that the retention of calcium and phosphorus was related to the quantity of sodium chloride in the feed and that when an increased excretion of phosphorus accompanies egg laying there is no concomitant change in the quantity of potassium in the droppings. Small concomitant increases in the sodium content of the droppings were observed when the feed contained only small quantities of sodium and chlorine. Notwithstanding the observations just mentioned, not much is known regarding the mechanism involved in the mobilization of calcium for egg shell formation and its subsequent deposition to form that structure.

Early in their studies of the calcium metabolism of egg-laying chickens, Buckner, Martin, and Peter (1925a) observed that the hatchability of the eggs is markedly diminished if the chickens do not receive a sufficient supply of calcium carbonate. Their later work (Buckner, Martin, and Peter, 1929) fully confirmed this observation. Hughes and associates (1924, 1925a, b, and c) found that ultra-violet irradiation had a definitely beneficial effect on the production and hatchability of eggs, and that the quantity of vitamin D stored in the eggs could be affected by diet as well as by ultra-violet irradiation of the chickens. Hart, Steenbock, Lepkovsky, Kletzien, Halpin, and Johnson (1925) also found that eggs produced on a diet deficient in vitamin D did not hatch well. However, fertility was not consistently affected by such a diet. In addition, Hart and associates found that the developing embryos from the eggs of irradiated hens contained, after 21 days of incubation, nearly twice as much lime as the embryos from the eggs of non-irradiated hens. More recently, Branion and Smith (1932) and Titus and Nestler (1935) have shown that an excess of vitamin D in the diet decreases egg production and the ability of the eggs to hatch.

Apparently, the quantitative aspects of the chicken's calcium and phosphorus requirements have not received much attention, at least until the last few years. The data of Common (1932) indicate that there is a minimum obligatory excretion of 0.15 gm. of calcium per day. Norris, Heuser, Ringrose, and Wilgus (1934) reported that 1.8 percent of calcium in the diet is optimum. Their studies on the relation of phosphorus to the calcium requirement showed that 0.50 percent of phosphorus in the diet was sufficient to maintain normal egg production and that 0.75 percent was adequate for this purpose. They concluded that 1 percent of phosphorus gave no better results than 0.75 percent. Miller and Bearse (1934) concluded that egg produc-

tion is influenced by the level of the phosphorus in the diet and reported that in their experiments the highest egg production was obtained on diets containing about 0.80 percent of phosphorus with two different levels of calcium intake. They also concluded that the quality of the egg shells and the weight of the eggs were not influenced by the level of phosphorus in the diet.

EXPERIMENTAL

Three experiments were conducted; the first in 1931-32, the second in 1932-33, and the third in 1934-35. Each experiment was started during September and was continued for a period of 48 weeks. Six pens of Single Comb White Leghorn pullets were used in the first experiment, six pens of Single Comb Rhode Island Red hens (yearlings) in the second, and six pens each of crossbred pullets and crossbred hens (yearlings) in the third. These crossbred chickens were the first generation resulting from mating Barred Plymouth Rock females to Single Comb Rhode Island Red males. There were 15 birds in each pen at the beginning of the first two experiments and 25 birds in each pen at the beginning of the third experiment. In all three experiments one Single Comb Rhode Island Red cockerel was placed in each pen. In all three experiments the males were moved progressively from pen to pen at intervals of three and four days.

The pens were of suitable size and were located in long laying houses. Adjoining each pen was a concrete-floored run-yard which permitted the birds to have access to direct sunlight but not to the soil.

The diets. In each of the first two experiments six different diets were used. All contained enough bone meal or mono-sodium-di-hydrogen phosphate to bring the phosphorus content to 1.2 percent. Three contained enough ground limestone and three enough calcium sulphate (gypsum) to give Ca/P ratios of 1.0, 2.5, and 4.5, respectively. In the diets having a Ca/P ratio of 1.0, only mono-sodium-di-hydrogen phosphate was used to bring the phosphorus content to 1.2 percent; and in the diets having Ca/P ratios of 2.5 and 4.5, only bone meal was used.

In the third experiment six different diets were again used. Three contained, as in the first two experiments, enough bone meal or mono-sodium-di-hydrogen phosphate to bring the phosphorus content to 1.2 percent, but the other three contained no added source of phosphorus and had a phosphorus content of 0.9 percent. In this experiment the diets also contained enough ground limestone to give Ca/P ratios of 1.0, 2.5, and 4.5, but there were no corresponding diets containing calcium sulphate. Each of the six diets was fed to one pen of crossbred pullets and one pen of crossbred hens.

The several diets were similar in every way, except that, as indicated above, they contained different kinds and quantities of calcium- and phosphorus-bearing mineral ingredients. All the diets were compounded as follows:

		Parts by weight
Desiccated meat meal		8
North Atlantic whitefish meal		7
Dried buttermilk		5
Special steamed bone meal (or mono-sodium-di-hydrogen phosphate in the case of all diets containing 1.2 percent of phosphorus and having a Ca/P ratio of 1.0)		enough to give the desired percentages of Ca and P
Ground limestone or calcium sulphate (gypsum)—as indicated in the text		
Anhydrous Na_2SO_4		0.5
Salt (NaCl)		0.5
Basal feed mixture	Parts by weight	enough to bring the total to 100 parts
Ground limestone	500	
Wheat bran	245	
Rolled oats	150	
Alfalfa leaf meal	55	
Total	950	
Total		100.0*

* To each 100 parts by weight of mixed feed was added 2 parts of high-grade cod-liver oil just before feeding.

The birds were given tap water (from a deep well) to drink. Chemical analyses made during the experiments showed that this water at no time contained more than very small traces of calcium and phosphorus.

The birds were trapnested in order to obtain complete records of their egg production. All the eggs obtained in both of the first two experiments were weighed on the same day they were laid. In the third experiment none of the eggs were weighed. Approximately five weeks after the beginning of each of the experiments eggs from the several pens were incubated for the first time. Thereafter, at intervals of four weeks in the first experiment, all the sound eggs laid during a period of one week were incubated. In the second experiment all the sound eggs laid during each week, except a few eggs which were used for other tests, were incubated. In the third experiment, at intervals of four weeks, all the sound eggs laid during a period of 13 days were incubated.

The incubated eggs were candled on the seventh and fourteenth days. All dead embryos were removed from the shells on these days and at the end of the incubation period; and the age at which death had occurred was estimated from the size of the embryos and from their morphological development.

In the first experiment determinations were made of the calcium and phosphorus content of the edible portion of small lots of eggs from each pen during the months of December, March, and June. In the second experiment, at intervals of four weeks, the breaking strength of the shells of all eggs laid during a single day was measured. At different times during the second experiment data were obtained on the water lost by the eggs during the first 18 days of incubation. At the end of the third experiment, the hemoglobin content of the blood of 10 birds taken at random from each pen was determined.

RESULTS

The data on egg production and hatchability for all 24 pens of chickens in the three experiments are summarized in Table 1.

Egg production is given as percentage of the total number of eggs which would have been produced if each pullet or hen had laid one egg each day of the experiment. Some deaths occurred during the experiments and, accordingly, before computing the percentage egg production, the average number of eggs laid per bird in each pen was adjusted by the method of covariance analysis. The co-variants were the number of eggs each bird laid and the number of days each bird lived. The data for each experiment were analyzed separately. The standard error of the adjusted average egg production of each pen was computed in the usual manner from the appropriate reduced variance. The adjusted averages and their standard errors were then divided by the average number of days the birds lived in order to obtain the figures given in the tenth column of Table 1.

The percentages of fertile eggs that hatched, and their standard errors, were computed by the method devised by Hendricks (1935).

An examination of the data in Table 1 shows that the pullets and the hens reacted differently—as indicated by their egg production and by the hatchability of their eggs—to the different levels of calcium intake. In general, egg production and hatchability were not affected in the same way.

There was a tendency for the pullets to lay more eggs as the percentage of calcium in the diet was increased, whereas in the case of the hens there was a tendency for egg production to increase at first and then to decrease as the calcium content of the diet was increased. On the lowest level of

TABLE 1.—*Egg production and hatchability of the fertile eggs*

When experiment was conducted	Breed of chicken	Age class of the chickens	Pen number	Chief source of added calcium in the diet[a]	Calcium content of the diet	Phosphorus content of the diet	Ca/P ratio of the diet	Number of birds in each pen at beginning of the experiment	Egg production[b]	Number of birds for which eggs were set	Total number fertile eggs set	Fertile eggs hatched[b]
					per cent	per cent			per cent			per cent
1931–1932	White Leghorn	Pullets	60	Calcium carbonate (ground limestone)	1.20	1.20	1.0	15	30.1±3.09	13	283	62.5±3.43
			62		3.00	1.20	2.5	15	45.2±2.91	15	984	75.2±3.46
			64		5.40	1.20	4.5	15	47.2±2.87	15	847	69.8±3.61
			61	Calcium sulphate (gypsum)	1.20	1.20	1.0	15	27.8±2.95	13	372	66.7±3.48
			63		3.00	1.20	2.5	15	45.6±2.89	15	590	59.7±5.21
			65		5.40	1.20	4.5	15	44.3±2.90	15	647	57.3±5.02
1932–1933	Rhode Island Red	Hens (yearlings)	82	Calcium carbonate (ground limestone)	1.20	1.20	1.0	15	31.8±3.96	11	504	68.3±3.89
			84		3.00	1.20	2.5	15	36.0±3.87	13	739	69.3±4.39
			86		5.40	1.20	4.5	15	29.5±3.91	9	650	60.9±7.04
			83	Calcium sulphate (gypsum)	1.20	1.20	1.0	15	33.0±3.90	14	917	71.8±5.37
			85		3.00	1.20	2.5	15	26.8±3.87	13	622	58.0±4.12
			87		5.40	1.20	4.5	15	30.6±3.91	15	755	46.1±5.50
1934–1935	Crossbred (F$_1$-generation resulting from mating Barred Plymouth Rock females to Rhode Island Red males)	Pullets	146	Calcium carbonate (ground limestone)	1.20	1.20	1.0	25	31.6±2.98	25	556	80.2±3.26
			144		3.00	1.20	2.5	25	45.0±2.98	22	826	81.4±2.44
			147		5.40	1.20	4.5	25	51.8±2.97	23	900	75.3±3.38
			140	Calcium carbonate (ground limestone)	0.90	0.90	1.0	25	26.2±2.97	22	356	79.5±4.17
			139		2.25	0.90	2.5	25	48.6±2.98	23	919	78.1±3.11
			142		4.05	0.90	4.5	25	48.0±2.98	23	1040	74.5±2.88
		Hens (yearlings)	137	Calcium carbonate (ground limestone)	1.20	1.20	1.0	25	38.0±2.98	22	451	82.5±3.39
			136		3.00	1.20	2.5	25	40.3±2.97	25	670	79.9±5.88
			138		5.40	1.20	4.5	25	35.0±2.98	21	470	70.0±5.87
			143	Calcium carbonate (ground limestone)	0.90	0.90	1.0	25	34.3±2.97	24	434	83.2±3.68
			141		2.25	0.90	2.5	25	46.0±2.98	24	820	81.0±2.62
			145		4.05	0.90	4.5	25	36.2±2.97	19	534	64.4±3.86

[a] The diets fed to pens 140 and 143 contained no added source of calcium.
[b] The figures following the ± signs are the standard errors of the figures immediately preceding the ± signs.

calcium intake the egg production of the pullets was always less than that of the hens, whereas on the highest level it was always greater.

In seven cases out of eight the lowest hatchability was associated with the highest level of calcium intake, and in five cases out of eight the highest hatchability was associated with the lowest level of calcium intake. Furthermore, on the highest level of calcium intake the hatchability of the pullets' eggs was always greater than that of the hens' eggs.

If one disregards the data for pen 85, the data for the other 11 pens in the first two experiments indicate that under the conditions of these experiments calcium sulphate was just as satisfactory as calcium carbonate for egg production. On the other hand, the hatchability of the eggs was better in most cases when calcium carbonate was the chief added source of calcium in the diet.

The data indicate that the phosphorus content of the diet had no statistically significant effect on either egg production or hatchability; however, in the case of the hens, the highest level of calcium intake affected the hatchability more adversely when the phosphorus content of the diet was 0.9 percent than when it was 1.2 percent. The writers' observations on the effect of the phosphorus content of the diet on egg production are not in agreement with Miller and Bearse's (1934) conclusions; but it should be pointed out that the phosphorus content of some of their diets was much lower than that of any of the diets used in the writers' experiments.

TABLE 2.—*Percentage of the embryos dying during the first four days and the last three days of incubation in the third experiment*

Pen no.	Age class of the chickens	Calcium content of the diet	Phosphorus content of the diet	Ca P ratio of the diet	Percentage of embryos dying	
					during first four days of incubation	during last three days of incubation
	Pullets	per cent	per cent		per cent	per cent
146		1.20	1.20	1.0	6.09	10.78
144		3.00	1.20	2.5	5.26	11.65
147		5.40	1.20	4.5	6.79	12.21
140	Pullets	0.90	0.90	1.0	4.78	11.98
139		2.25	0.90	2.5	4.42	15.04
142		4.05	0.90	4.5	6.38	17.33
137	Hens (yearlings)	1.20	1.20	1.0	5.35	9.61
136		3.00	1.20	2.5	5.55	12.26
138		5.40	1.20	4.5	7.33	18.41
143	Hens (yearlings)	0.90	0.90	1.0	5.64	8.18
141		2.25	0.90	2.5	4.90	11.65
145		4.05	0.90	4.5	5.99	25.50

Usually, the mortality rate of the embryos is greatest during the first four and the last three days of incubation, and is much greater during the latter period than the former. In order to show the effect of the calcium and phosphorus content of the diet of laying chickens on the time of occurrence of the embryonic mortality, data from the third experiment are presented in Table 2. Data for the first two experiments are not given, because the phosphorus content of all the diets in these two experiments was the same, that is, 1.2 percent. At this level of phosphorus intake, varying the calcium content of the diet had very nearly the same effect on the age-distribution of em-

bryonic mortality in all three experiments.

The data in Table 2 show that, regardless of whether the chickens were pullets or hens, or whether the phosphorus content of the diet was 0.9 or 1.2 percent, the percentage of embryos dying during the last three days of incubation increased as the calcium content of the diet was increased. No similar effect was observed on the mortality which occurred during the first four days of incubation; however, it may be noted that in three cases out of four the lowest mortality during this period was associated with the intermediate levels of calcium intake of the chickens.

Apparently, the effect of the phosphorus content of the diet on embryonic mortality is dependent on the calcium content. On the highest levels of calcium intake, that is, 4.05 and 5.4 percent, the percentage of embryos dying during the last three days of incubation was greater when the diet of the chickens contained 0.9 percent of phosphorus than when it contained 1.2 percent. This was true of the embryos in the pullets' eggs as well as of the embryos of the hens' eggs.

The data obtained on (1) the calcium and phosphorus content of the edible portion of the eggs, (2) the breaking strength of the egg shells, (3) the moisture lost during the first 18 days of incubation, (4) egg weight, and (5) the hemoglobin content of the blood of the chickens at the end of the experiment are not given, because none of these five items was significantly affected by the calcium or phosphorus content of the diet.

DISCUSSION

It was observed in these experiments that pullets lay more eggs than hens when the level of calcium intake is high but fewer eggs when the calcium intake is low. It is a matter of common experience that on an adequate diet pullets usually lay more eggs than hens and that the annual egg production of chickens decreases with age. Furthermore, pullets ordinarily continue to grow for several months after they begin to lay and thus have a small additional requirement of calcium for growth. These facts, taken together with the fact that hens usually eat more feed than pullets of the same breed and thus, on a given diet, have more calcium for egg shell formation, may be used to explain the observation that, so far as egg production is concerned, pullets and hens react differently to both high and low levels of calcium intake. Nevertheless, it is clear that the calcium requirements of pullets and hens are different and that when it is desired to obtain the best possible egg production this fact should be considered in compounding the diets.

Perhaps the most striking observation made was that the hatchability of the eggs of both hens and pullets tended to be distinctly the poorest on the two highest levels of calcium intake, that is, when the diets contained 4.05 and 5.4 percent of calcium, respectively.

Inasmuch as both egg production and hatchability are not affected in the same way by varying the calcium content of the diet, it is of considerable practical importance to adjust the calcium content of the diet so as to obtain both good egg production and good hatchability. A method of making such an adjustment is suggested by the fact that phosphorus is excreted as dicalcium phosphate, if there is enough calcium available (Knowles, Watkin, and Hendry, 1933; and Common, 1933). Such a method should be equally applicable for adjusting the calcium content of the diet of both pullets and hens, because one may readily conclude from data published by Mitchell, Card, and Hamilton (1926, 1931) that a pullet does not store more than 6 or 7 gm. of calcium in her body during the first five or six months after she begins to lay. If the calcium content of the diet is properly adjusted, the quantity stored by

the pullet in completing her growth is only a small percentage of the total quantity ingested.

On the assumption that 2 gm. of calcium and 0.108 gm. of phosphorus are used in the formation of an average egg and that it is desirable to supply enough additional calcium to permit all the excreted phosphorus to be eliminated as di-calcium phosphate, one may readily estimate the percentage of calcium required in the diet for any given rate of egg production. The method of making the estimate and the assumptions involved are indicated by the following equation:

$$Ca = \frac{1.292\ (PF - 10.8E) + 200E}{F}$$

in which,

Ca = the required percentage of calcium in the diet;

1.292 = the ratio of calcium to phosphorus in di-calcium phosphate;

P = the percentage of phosphorus in the diet;

F = the number of grams of feed consumed by a laying chicken during a year (this quantity will depend on the breed of chickens and the number of eggs produced, because the heavier breeds consume more feed than the lighter breeds and, of two chickens of the same breed and weight, the one producing the most eggs will, in general, require the most feed);

10.8 = 100 times the quantity (in grams) of phosphorus in an average egg;

E = the number of eggs produced in one year (this number will depend on the breeding of the chicken); and

200 = 100 times the quantity (in grams) of calcium in an average egg.

This method was applied to the diets used in the writers' experiments and it was assumed that the chickens were capable of laying, on an average, 200 eggs per year. The observed average feed consumption was used. It was found that the proper quantity of calcium in the diet, when calculated in this way, varied from 1.95 percent for the crossbred hens to 2.20 percent for the White Leghorn pullets, when the phosphorus content was 0.9 percent; and from 2.33 percent to 2.58 percent, when the phosphorus content was 1.2 percent. It will be noted that of the six dietary calcium levels studied, the two intermediate levels, that is, 2.25 and 3.0 percent, agree most closely with the calculated values and that, in general, it was only with these two intermediate levels that both good egg production and good hatchability were obtained simultaneously.

In using the method given above, account must be taken of the age of the chickens and of their breeding, inasmuch as both these factors determine to a considerable extent the quantity of feed that will be consumed and the number of eggs that will be laid. The calcium compound to be added to the diet in order to obtain the desired percentage of calcium should be one containing an acid radicle which is readily oxidized in the body or which, at least, does not require a base for its excretion. At present, high-grade limestone and oyster shell are the two most economical sources of calcium for poultry diets.

The writers believe that this method of controlling calcium intake is theoretically sound, and that it will produce satisfactory results, if properly applied. It is applicable only if the all-mash system of feeding is employed, but with suitable modification it may be applied when both dry mash and grains are fed.

SUMMARY

1. In a series of three experiments, diets containing different percentages of calcium and phosphorus were fed to laying pullets and hens (yearlings). In the first two experiments the phosphorus content of all the

diets was fixed at 1.2 percent and the calcium content was adjusted, by adding calcium carbonate (limestone) to one set of three diets and calcium sulphate (gypsum) to another set of three diets, so as to obtain levels of calcium intake of 1.2, 3.0, and 5.4 percent in each set. In the first experiment the resulting six diets were fed to pullets and in the second experiment they were fed to hens. In the third experiment one set of three diets contained 1.2 percent of phosphorus and another set of three contained 0.9 percent, and the calcium content was adjusted by adding calcium carbonate so as to obtain levels of calcium intake of 1.2, 3.0, and 5.4 percent when the phosphorus content was 1.2 percent, and levels of 0.9, 2.25, and 4.05 percent when the phosphorus content was 0.9 percent. In this last experiment each of the resulting six diets was fed to one pen of pullets and one pen of hens.

2. The pullets and hens did not react in the same way to the lower and the higher levels of calcium intake. On the lowest levels of calcium intake (0.9 and 1.2 percent) the hens laid more eggs than the pullets, but on the highest levels of calcium intake (4.05 and 5.4 percent) the pullets laid more eggs than the hens.

3. In general, a high level of calcium intake adversely affected the hatchability of the eggs, and the effect was more pronounced in the case of the hens' eggs than it was in the case of the pullets' eggs.

4. Calcium sulphate (gypsum) was just as satisfactory for egg production as calcium carbonate, but the hatchability of the eggs was better when calcium carbonate was the source of calcium.

5. The level of phosphorus intake had no statistically significant effect on egg production or hatchability; however, the highest levels of calcium intake affected the hatchability more adversely when the level of phosphorus intake was 0.9 percent than when it was 1.2 percent.

6. The percentage of embryos dying during the last three days of incubation increased as the level of calcium intake of the chickens was increased.

7. On the highest levels of calcium intake the percentage of embryos dying during the last three days of incubation was greater when the diet of the chickens contained 0.9 percent of phosphorus than when it contained 1.2 percent.

8. A :nethod is given for estimating the percentage of calcium required in the diet for any given rate of egg production.

9. It is suggested that the level of calcium intake of laying chickens should be controlled and that such control be based on the phosphorus content of the diet, feed consumption, and the potential egg-laying capacity of the chickens. In planning such control, it should be kept in mind that age, live weight, and egg production determine to a considerable extent the quantity of feed that will be consumed.

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The Dissection of a Frequency Distribution into Two Normal Components

Walter A. Hendricks
Bureau of Animal Industry, United States Department of Agriculture, Washington, D.C.

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In a recent paper Hays (1936) reported an attempt to separate the distribution of "age at first egg" for 230 Rhode Island Red pullets, reared at the Massachusetts Station, into two normal components. This dissection was attempted in order to test the hypothesis that the group of birds under consideration consisted of two distinct phenotypes for "age at first egg." The results obtained served as the basis for the conclusion that there appeared to be a definite phenotype with an age range from 130 to 179 days, but that the group of birds with an age range from 180 days upward consisted of more than one phenotype.

It appeared to the author of the present paper that the above-mentioned data could be adequately explained by the hypothesis that only two phenotypes were involved and that the distribution of "age at first egg" for this particular group of birds could be satisfactorily resolved into two component normal distributions.

The problem of dissecting a frequency distribution into two normal components apparently was first attacked successfully by Pearson (1894). His solution is based on an application of the method of moments and involves the solution of a set of six simultaneous equations, only one of which is in a linear form with respect to the constants which must be determined. The evaluation of the constants by means of these equations depends upon the solution of an algebraic equation of the ninth degree and involves considerable labor, but apparently a simpler procedure which attains the same degree of accuracy has never been found.

The present paper gives the results of applying Pearson's method of analysis to Hays' data.* It will be shown that the data

Table 1.—*Constants of the two normal components of the distribution of "age at first egg" for 230 Rhode Island Red pullets reared at the Massachusetts Station*

Constant	First component	Second component
Number of individuals	77.068	152.932
Arithmetic mean	161.206	203.006
Standard deviation	11.535	14.439

Table 2.—*Observed and theoretical distributions of "age at first egg" for 230 Rhode Island Red pullets reared at the Massachusetts Station*

"Age at first egg" (days)	Number of birds	
	Observed	Theoretical
Less than 145	7	6.17
145–154	17	16.65
155–164	21	26.31
165–174	30	23.03
175–184	16	19.64
185–194	27	29.43
195–204	47	40.71
205–214	37	37.02
215–224	15	21.29
225–234	12	7.72
235 and over	1	2.04
Total	230	230.01

* The actual data were not given in Dr. Hays' paper but were supplied to the present author for the work herein reported. The author wishes to take this opportunity to express his thanks to Dr. Hays for his friendly interest and generous cooperation in the investigation.

can be adequately explained by assuming the presence of only two phenotypes in the group of birds under consideration.

The observed distribution of "age at first egg" for the 230 birds is represented by the histogram in Figure 1. The class intervals chosen for grouping the data are somewhat vals adopted in the present study are more satisfactory, from this point of view, than those used by Hays.

The smooth curve in Figure 1 represents the theoretical distribution, which is the resultant of the two normal distributions which were found by Pearson's method of

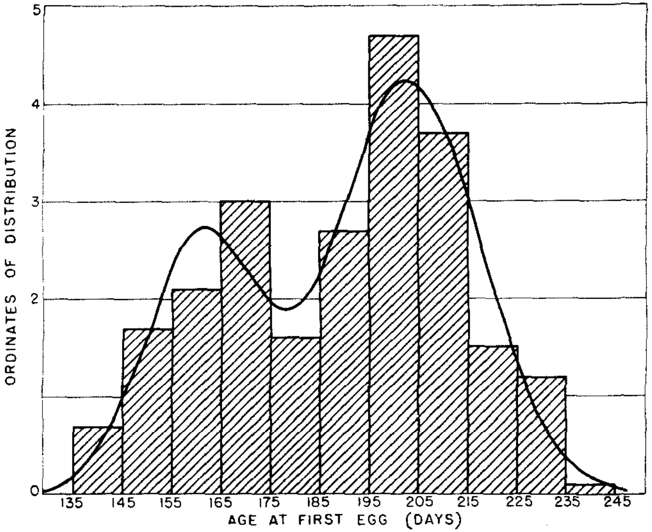

FIG. 1. Observed and theoretical distributions of "age at first egg" for 230 Rhode Island Red pullets reared at the Massachusetts Station.

different from those used by Hays. The application of Pearson's technic to the data as originally grouped indicated that the means for the two phenotypes were approximately 160 days and 202 days, respectively. When dealing with normal distributions, it is usually desirable to use a system of grouping which will make the means of the distributions fall near the midpoints of the classes containing them. The class inter- analysis after the new system of grouping was adopted. The constants of these two normal distributions are given in Table 1.

The observed and theoretical numbers of birds for each class interval are given in Table 2.

The agreement between the observed and theoretical frequencies in Table 2 is fairly good. If the observations in the last two class intervals are grouped into one class,

the application of the chi-square test to the data shows that the degree of discrepancy between theory and observation in Table 2 could arise by chance about once in 11 trials.

Hays' data can, therefore, be adequately explained by the hypothesis that only two phenotypes for "age at first egg" were present in the given group of birds. The amount of confidence which can be placed in this conclusion is probably greater than the above results seem to indicate. Fisher (1921) has shown that the method of moments, as applied to curve fitting, does not always give the best possible agreement between the observed and fitted curves. However, since the method of moments yielded a good fit in the present problem, there does not seem to be any necessity for attempting to improve the results by a more laborious procedure.

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Fluctuations of Calcium and Inorganic Phosphorus in the Blood of the Laying Hen During the Cycle of One Egg[1]

J. G. FEINBERG, J. S. HUGHES, AND H. M. SCOTT
Kansas Agricultural Experiment Station, Manhattan, Kansas

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THE calcium content in the blood of the laying hen during the approximately 26 hours of a single egg cycle has recently been studied by several investigators with a variety of results.

Charles and Hogben (1933) reported that the presence of an egg in the oviduct is accompanied by a transitory rise in blood calcium. However, their results are unreliable because they sacrificed the hen to determine the position and condition of the egg and thus had to use a different hen for each determination. It has been demonstrated by various workers that the calcium level in the blood of laying hens varies greatly among the individual hens so, unless the same hen is used for each set of bleedings, the results obtained are not comparable.

Knowles, Hart, and Halpin (1935) used the same hen for each series of bleedings and obtained results in opposition to those of Charles and Hogben. They reported a variation in the calcium content during the laying cycle but found a low level corresponding to the time of shell deposition and a high level when there was no egg in the shell gland.

However, the following year Deobald, Lease, Hart, and Halpin (1936) repudiated these previous findings and stated that the calcium content in the blood of the individual hen was nearly constant, varying only within narrow limits during a complete egg cycle.

Though a knowledge of the inorganic phosphorus level in the blood of the laying hen during the egg cycle would be of great interest because of its relation to calcium metabolism, a search of the literature fails to reveal any reported investigation of this problem.

In this paper, further data on the calcium content of the blood of laying hens are presented and in addition, the results of an investigation of the inorganic phosphorus content.

METHOD

Laying hens were bled from the wing vein at intervals during the single egg cycle, one hen being used for each complete set of bleedings. Three bleedings corresponding to various shell-depositing and non-shell depositing periods were made and about 2 to 3 c.c. of blood collected at each bleeding.

Period 1 represents the interval immediately after oviposition. Period 2 represents the period of active shell deposition. This period was determined, without sacrificing the hen, by digital cloacal manipulation. By this method, a soft shell egg can be detected in the uterus. That this interval, 11½-13 hours after oviposition represents a time of rapid shell deposition was demonstrated in the work of Warren and Scott (1935). Period 3 represents 26 hours after

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oviposition, or about the time for a second oviposition.

The control non-laying hens were bled at approximately the same time as were the laying hens. This served to eliminate the possibility of any diurnal factor.

The calcium and inorganic phosphorus were determined by a slight modification of the method of Fiske and Subbarow (1925).

RESULTS

The analysis of the blood serum of seven laying hens and one non-laying hen revealed a relative constancy of the calcium level during the various stages of egg formation in a single egg cycle. The average calcium level for the seven laying hens for period 2 was found to be 98.5 percent and for period 3, 92 percent of the amount in the first period. The calcium level was also constant for the non-laying control hen, being 100 percent and 97.5 percent for periods 2 and 3 respectively.

However, the inorganic phosphorus level showed an entirely different picture. Though the inorganic phosphorus content of the blood of five non-laying hens was found to vary over but a small range, a significant increase was observed in the inorganic phosphorus of the blood of ten laying hens during the period corresponding to shell formation. Thus, for periods 2 and 3 respectively, the inorganic phosphorus level in the blood of non-laying hens was found to be 113.5 percent and 111 percent of that found in the first period while for the laying hens the level increased to 177.5 percent during the period of shell deposition and then fell to 116.5 percent. The results of the analyses are presented in Table 1.

DISCUSSION

The results obtained for the calcium analysis serve to confirm the findings of Deobald, Lease, Hart, and Halpin, that the calcium level varies within only narrow limits during the egg cycle. The diurnal fluctuation in the calcium in the blood of fowls is proportionately no greater than the diurnal variation of calcium in mammalian blood. This would indicate then that the hen has available a ready reserve of calcium

TABLE 1.—*Average level of calcium and inorganic phosphorus in the blood serum of laying hens at different stages of egg formation and of non-laying hens*

Bleeding period	Mgs. calcium per 100 cc. of blood serum		Mgs. inorganic phosphorus per 100 cc. of blood serum	
	Non-laying hens	Laying hens	Non-laying hens	Laying hens
1	16.2	24.7	3.7	4.2
2	16.2	24.3	4.2	7.5
3	15.7	22.7	4.1	4.9

from which she can draw calcium as rapidly as it is being deposited in the shell, so that at the time of shell deposition the calcium level of the blood does not fall.

The rise in inorganic phosphorus has, seemingly, but one possible explanation. The reserve store of calcium mentioned above must be in the form of bone. This view is substantiated by the findings of Deobald, Lease, Hart, and Halpin that about 10 percent of the bone of hens on a liberal calcium ration is available for shell formation and, further, by the work of Kyes and Potter (1934) in which it was demonstrated that pigeons in a laying condition showed ossification of the bone marrow while males and non-laying females did not. As the calcium is drawn from the calcium phosphate of the bones to be laid down as calcium carbonate in the shell, inorganic phosphate is liberated and manifests itself in the increased inorganic phosphorus level of the blood.

It is of interest that the above explanation is essentially the same as the one offered by Common (1932, 1933, 1936) regarding his

work with the excreta of hens. He found a rise in the phosphorus content of the excreta corresponding to the period of shell formation and attributed the excess phosphorus to phosphate set free when the calcium was removed from the bones for shell formation. He demonstrated that the excess phosphorus was present in the excreta as ammonium phosphate and probably came through the urinary route.

CONCLUSIONS

1. Analysis of the blood serum of seven laying hens and one non-laying hen demonstrated that the calcium level in each was relatively constant during the 26-hour period of a single egg cycle.

2. Analysis of the blood serum of 10 laying hens and five non-laying hens for inorganic phosphorus during a similar period revealed a marked rise in the phosphorus level in the blood of the laying hens during the period of shell formation whereas the phosphorus level in non-laying hens was relatively constant.

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The Relation of the Carotenoid Pigments of Feed to the Carotenoid Pigments of Egg Yolk*

J. S. HUGHES AND L. F. PAYNE
Kansas Agricultural Experiment Station, Manhattan, Kansas

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THE work of Schunck (1903), Palmer and Kempster (1919), Kuhn and Grundmann (1933), Brockman and Volker (1934), and Gillam and Heilbron (1935) shows that the carotenoid pigments present in egg yolk consists almost entirely of xanthophyll with only a small amount of cryptoxanthin and carotene. So far no experiments have been reported which give quantitative data concerning the relation of the amounts of these carotenoid pigments in the feed to the amount of these pigments in the egg yolk. This paper presents the results of two experiments which give some data on this quantitative relationship.

In the first of these experiments the source of the pigments was kept constant while the amount in the rations varied, in the second experiment the amount of pigments in the ration was kept constant while the source of the pigments was varied.

EXPERIMENT I

The object of this experiment, which was conducted in the spring of 1934, was to determine the amount of carotenoid pigments that would be deposited in egg yolk when definite amounts of these pigments were incorporated in the feed by the use of yellow corn. To secure this information, hens were first depleted of carotenoid pigments by feeding them a ration low in pigments.

When the yolks of the eggs produced were of a uniform light color—almost devoid of pigments—the hens were given a definite amount of carotenoid pigment by supplementing the basal ration with yellow corn. All the eggs pigmented as a result of feeding the corn were collected and the amounts of pigments contained were determined.

Four lots of four Leghorn hens each were used in this experiment. After a three weeks' preliminary period on the basal ration, each of the hens in lot I was given 10 grams of yellow corn per day for a period of twenty-one days. Those in lot II were given 20 grams and those in lot III, 30 grams, while lot IV was continued on the basal ration. The corn was placed directly in the crop of each bird with a suitably constructed funnel. After the corn feeding period, all the hens were continued on the basal ration for a period of twenty-one days after which time the yolks of the eggs from the hens which had been fed corn (those in lots I, II, and III) were as low in pigment content as those from the hens in lot IV which had been on the basal ration all the time.

The amounts of carotenoid pigment in the basal ration and the yellow corn were determined by the method of Schertz (1928), using the spectrophotometer for the final estimation of the pigments. In this method the pigments are divided into the alcohol phasic fraction consisting largely of xanthophylls and petroleum phasic fraction consisting largely of carotenes and cryptoxanthin. No attempt was made to separate these two fractions into the individual pigments which they contain.

* Contribution No. 214, Department of Chemistry, Contribution No. 104, Department of Poultry Husbandry.

TABLE 1.—*Average amount of carotenoid pigments in the egg yolks of hens receiving varying amounts of yellow corn*

Lot No.	Mgs. of Pigments in the corn* fed		Mgs. of Pigments in yolk in excess of amount** in controls		Percent of corn Pigments deposited in egg yolks	
	Crypto-xanthin and Carotene	Xanthophyll	Crypto-xanthin and Carotene	Xanthophyll	Crypto-xanthin and Carotene	Xanthophyll
A	1.13	4.47	.133	0.781	12.0	17.4
B	2.26	8.95	.144	1.910	6.4	21.4
C	3.39	13.42	.164	3.160	4.8	23.5

* One gram of corn contained 0.00538 mgs. of cryptoxanthin and carotene and 0.0213 mgs. of xanthophyll.
** The hens on the basal ration receiving no corn deposited an average of 0.03 mgs. of cryptoxanthin and carotene and 0.131 mgs. of xanthophyll in their yolk.

The yolks produced by each hen were pooled, and samples taken for analysis. The amounts of pigment in all the eggs produced by each hen in each of the four lots during the corn feeding period and the following twenty-one-day period were determined. The results of the analysis are summarized in Table 1.

TABLE 2

	Lot I	Lot II	Lot III	Lot IV
White corn	41.5	41.5	41.5	0.0
Yellow corn	0.0	0.0	0.0	41.5
Ground wheat	25.5	25.5	25.5	25.5
Ground oats	10.0	10.0	10.0	10.0
Meat and bone scrap	10.0	10.0	10.0	10.0
Dried buttermilk	5.0	5.0	5.0	5.0
Alfalfa meal	0.0	0.0	3.0	0.0
Corn starch	3.0	3.0	0.0	3.0
Oyster shell	2.0	2.0	2.0	2.0
Bone meal	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0
Cod liver oil	1.0	1.0	1.0	1.0
*Green buttermilk	0.0	6.5	0.0	0.0

* Green buttermilk is made by condensing chopped fresh green barley with buttermilk.

These results are in accord with the well known fact that the alcohol phasic fraction of the carotenoid pigments is deposited in egg yolk in greater concentration than the petroleum phasic fraction. They also show that the percentage of the alcohol phasic fraction, the xanthophylls, of the feed deposited in the egg increased as the amount of corn was increased in the ration. The hens receiving 10 grams of corn per day deposited 17.4 percent of the xanthophyll in the egg, while those receiving 20 and 30 grams of corn deposited 21.4 and 23.5 percent respectively.

The variations between individual hens were much greater with the petroleum phasic fraction than with the alcohol phasic fraction. One hen in lot A receiving 10 grams of corn daily deposited in her egg yolks 37 percent of cryptoxanthin and carotene which she received from the corn in her ration while another hen in the same lot deposited only 0.65 percent of these pigments in her yolk. No such variation was found in the case of the alcohol phasic fraction.

EXPERIMENT II

In experiment I three levels of yellow corn were fed, namely, 10, 20, and 30 grams per hen per day. In the second experiment this series was continued by feeding lot IV 40 grams of corn per day. In addition to continuing the work on yellow corn, two other sources of carotenoid pigments, dehydrated

TABLE 3

Feed	Mgs. Carotenoid Pig. in 100 gms. feed	
	Petrol. phasic frac. (Carotene and Crypt.)	Alcohol phas. frac. (Xanthophyll)
White Corn, Lot I	0.08	0.18
Green Barley, Lot II	0.43	0.86
Dehyd. Alfalfa, Lot III	0.49	0.92
Yellow Corn, Lot IV	0.29	0.94

alfalfa and young green barley, were used. The barley was supplied in the form of green buttermilk, a product made by grinding the young plant, mixing the ground mass with buttermilk, and condensing the mixture in a vacuum. The alfalfa and the barley were fed in such amounts so as to furnish about the same amount of the alcohol phasic fraction, the xanthophylls, as was furnished by the yellow corn.

these results. Since both the method of feeding the corn and the method of chemical analysis were different in the two experiments, the agreement between the results indicates the reliability of the data secured.

The results of this experiment show a marked similarity in the metabolism of the pigments derived from the green leaves, alfalfa and barley. Although each of these leaves contains a high amount of the petro-

TABLE 4.—*Average mgs. of carotenoid pigments in the feed consumed by hens in a seven day period and in the egg yolks produced during the same period*

Source of Pigment in the Ration	Av. No. of Eggs Produced per hen	Av. No. Mgs. Pig. in Feed Consumed		Av. No. Mgs. Pig. in Yolk Prod.		% Pig. Depos. in Egg Yolk	
		Petrol. Fract.	Alcohol Fract.	Petrol. Fract.	Alcohol Fract.	Petrol. Fract.	Alcohol Fract.
Green Barley	4	3.28	6.57	0.086	1.04	2.62	15.84
Dehyd. Alfal.	4.4	3.48	6.54	0.087	1.03	2.50	15.75
Yellow Corn	5	2.28	7.38	0.161	1.90	7.07	25.73
Control	2.5	0.61	1.38	0.000	0.03	0.00	2.18

The rations used are listed in Table 2. These feeds were analyzed for carotenoid pigments by the Peterson Modification (1936) of the Guilbert (1934) Method with the results shown in Table 3.

Four lots of eight hens each were used in this experiment. They were kept in individual hen batteries equipped with feeding cups so that accurate records of feed consumption could be secured. The hens were fed the experimental rations for three weeks before eggs were saved for analysis. All the eggs produced the fourth week were analyzed for carotenoid pigments by the same method used in analyzing the feeds. The results of these chemical analyses are given in Table 4.

The percent of pigments from the corn deposited in the egg yolk is just the percent which would have been expected from the results in the first experiment. In the first experiment 17.4, 21.4, and 23.5 percent of the alcoholic phase of the pigment were deposited in the yolk when 10, 20, and 30 grams of corn were fed. The 25.73 percent deposited in this experiment is in line with

leum phasic fraction, which is almost pure beta carotene, very little of this fraction was deposited in the egg. Only 2.62 percent of this fraction was deposited in the case of green barley and 2.5 percent in the case of dehydrated alfalfa. The percent of the alcohol phasic fraction, xanthophylls, was almost the same for the two leaves, being 15.84 percent for green barley and 15.75 percent for dehydrated alfalfa.

A much higher percentage of each fraction of the pigment of yellow corn was deposited, that is, 7.07 percent for petroleum phase and 25.73 percent of the alcohol phase. This high deposition of the petroleum fraction of the corn is no doubt due to the high percentage of cryptoxanthin which this fraction from yellow corn contains. This pigment contains one hydroxyl group which tends to give it proporties resembling somewhat the xanthophylls. Since xanthophylls are deposited in the egg yolk in fairly high concentration, but carotenes only in small amounts, one might expect cryptoxanthin from yellow corn which resembles xanthophyll in structure to be deposited in higher

concentration than the carotene from leaves.

The greater deposition of the alcohol phasic fraction from the corn is no doubt due to the type of xanthophylls which are found in corn. Karrer (1929) isolated from the alcohol phasic fraction of yellow corn a xanthophyll which he designated as zeaxanthin. The exact structure of this compound has not been determined.

This higher deposition of corn pigments in the egg yolk is in accord with the experience of poultry men who have found that yellow corn in the ration has a marked effect on the color of egg yolks.

It is an interesting fact that hens deposit a much higher percent of the alcohol phasic fraction of the carotenoid pigments in the egg than the petroleum phasic fraction, while cows deposit much more of the petroleum phasic fraction than the alcohol phasic fraction in their butter. This difference in the absorption and metabolism of carotenoid pigments by different species offers an interesting field for study.

SUMMARY

As the amount of yellow corn was increased in the ration of laying hens the percentage of the alcohol phasic fraction of the carotenoid pigments (xanthophylls) deposited in the egg yolk increased. When 10, 20, 30 and 40 grams of corn were fed each day, the percentages of this fraction of the pigments deposited were 17.4, 21.4, 23.5 and 25.7 respectively.

The percentage of the petroleum phasic fraction of the carotenoid pigments of yellow corn (carotene and cryptoxanthin) deposited in the egg yolk differs widely with different hens. The average amounts deposited when 10, 20, 30 and 40 grams of yellow corn were fed daily were 12.0, 6.4, 4.8 and 7.0 respectively.

When yellow corn, green barley, and dehydrated alfalfa were fed in such amounts as to provide approximately 1 mg. of the alcohol phasic fraction of the carotenoid pigments (xanthophylls) per day, 25.7 percent of the corn pigment, 15.8 percent of the barley pigment, and 15.7 percent of the alfalfa pigment were deposited in the yolks.

Only 2.6 percent of the carotene from green barley and 2.5 percent of the carotene from dehydrated alfalfa were deposited in the egg yolk.

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Poultry Husbandry in the Agricultural College Curriculum, Elective or Required

W. C. Tully

Virginia Polytechnic Institute

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THOUGH the poultry industry has grown rapidly in the past decade, many college poultry departments have, for one reason or another, been unable to broaden their work with students. Despite the facts that the poultry industry ranges from second to fourth in value of all agricultural products produced, and that any improvement in poultry methods benefits more farms than any other agricultural commodity, too many poultry departments have not kept pace with the rapidly expanding industry. To cite just one example in some colleges the number and variety of poultry courses have not kept up with the industry. Other institutions have found that too rapid multiplication of poultry courses has resulted in too few students in proportion to the number of advanced courses offered. In view of this situation, it is well to consider available information and to promote thought on this problem.

A 1931 survey of 21 agricultural colleges in different sections of this country shows general poultry hubandry to be regularly offered in the four year course. For many years the poultry industry has been important enough to warrant such action.

However, when considering whether this general poultry course should be elective or required, amazing differences of both opinion and practice were found. Nine of these 21 colleges required four year students to take poultry; five required it except for students in certain curricula; five made it optional; one required it only for agricultural education major students; and one college did not specify.

Table 1 gives the results of a similar but more extended survey made during the summer of 1936. Columns 1 to 6 refer to the following questions:

In the regular four year course in agriculture:

1. Is a course in general poultry husbandry required?
2. If this course is required for only those majoring in certain fields, please state which these are.
3. If required, in which year must poultry be taken?
4. General poultry husbandry is a ——— semester, quarter (cross out one) credit course.
5. In the 1935-36 college year ——— junior students were taking a major in poultry husbandry or industry.
6. In the same college year ——— senior students took a major in poultry hushandry or industry.
7. Have you objections to publication of answers to questions 5 and 6? If so, would you like a separate report of same?

Of the forty-six colleges to which the query was addressed, forty-one replied. Only five did not choose to answer either of two requests. The following data and and percentages are based, therefore, on these replies from forty-one colleges. All but one are in the United States.

TABLE 1

	General Poultry Required	Required Only for These Options	General Poultry Is Given, Year	General Poultry, Credit for Course	Major students: 1935–36 college Year	
					Juniors	Seniors
Arkansas	Yes	—	1	2, s.	No major offered	
California	No	—	—	3, s.	*(1)	*(1)
Colorado	No	—	—	5, s.	0*(18)	0*(18)
Delaware	No	Animal Indus., Ag. Ed.	3	6, s.	0	0
Florida	Yes	—	2	*(7)	0*(8)	0*(8)
Georgia	Yes	*(11)	1	1, q.	6	6
Idaho	No	All Agriculture except Ag. Chem. or Ag. Bact.	1	1, s.	1*(17)	0*(17)
Illinois	No		3 & 4 *(12)	3, s.	0	10*(13)
Indiana	No	Agr. Ed.	4	3, s.	*(1)	*(1)
Iowa	No	A. H., Dairy H., Dairy Indus. & Economics, Agronomy, Voc. Ed.	2	3, q.	6	2
Kansas	Yes *(15)	—	2	2, s.	6	2
Kentucky	Yes	—	1	2, s.	6*(2)	6*(2)
Louisiana	Yes	—	1	1, s.	*(9)	1
Maine	Yes	—	1	3, s.	1	1
Maryland	Yes *(16)	—	3	3, s.	2	3
Massachusetts	No	—		5, s.	3*(4)	3*(4)
Michigan	No	*(15) For all except Hort., Landscape Arch., Forestry	2 or 3	3, q.	8	3
Minnesota	No	—	—	1, q.	2	—
Mississippi	Yes	—	2	3, s.	2	1*(5)
Missouri	Yes	—	1	3, s.	0	8
Nebraska	Yes	*(20)	1 or 2			
New Hampshire	Yes	—	1 or 2	3, s.	10	4
New Jersey	No	For all except landscape gardening, floriculture, soil science	2	3, s.	3	2
New York	No	Extension, Agri. Ed., Vet. Med.	—	3, s.	10*(10)	9*(10)
North Carolina	Yes	—	2		3	2
North Dakota	Yes	—	2	3, q.	0	0
Ohio	No	Vet. Med., Voc. Agr., Animal Science	1, 2, 3, 4 except Vet. Sci. 3	5, q.	4	2

TABLE 1 (*continued*)

	General Poultry Required	Required Only for These Options	General Poultry Is Given, Year	General Poultry, Credit for Course	Major students: 1935-36 College Year Juniors	Seniors
Oklahoma	Yes	—	Usually 1 or 2	3, s.	10	7
Oregon	No	Required for all agriculture except Food Products, Agri. Tech., Ag. Engin., Landscape Arch.	1	3, q.	4	2
Pennsylvania	No	Agr. Ed., A. H., Dairy, Poultry	2*(6)	3, s.	10	3
Rhode Island	Yes	—	1	1, s.		
South Carolina	No	For all except Ag. Engin.	3	2-2/3, s.	No major offered	
South Dakota	Yes	—	2 or later	3, q.	*1	*1
Tennessee	Yes	—	1	3, q.	*(14)	*(14)
Texas	No	Rural Ed., Vet. Sci., Voc. Ag., Poultry Science	2	3, s.	7	5
Utah	No *(3)	—	*(3)	3, q.	2	2
Virginia	No	Ag. Ed., Gen. Ag.	3	3, q.	No major offered	
West Virginia	Yes	—	2	4, s.	No major offered	
Wisconsin	No	—	2, 3, 4	3, s.	0	6
Wyoming	No	Animal Production	2, 3 or 4	3, q.	3	2
Ontario Agricultural College	Yes	—				*(19)

s.—on a semester basis.
q.—on a quarter basis.
*(1) Requested not to publish information.
*(2) Students "elect" and do not major or minor. 6 juniors and 6 seniors took all the poultry courses offered.
*(3) Poultry is one of seven orientation courses. Six of the seven are required, and four of these must be taken in the first or second years.
*(4) The two year agricultural course, giving 25 to 30 semester hours of poultry, draws most poultry majors. They take somewhat the same as those in the four year course. From 12 to 25 major in this each year. If this course were not offered, the majors in the four year course might double.
*(5) Do not encourage students to major in poultry industry.
*(6) Poultry majors take poultry in freshman year.
*(7) 18-20 poultry lectures as part of required Animal Science course.
*(8) Major in poultry husbandry set up only in fall of 1935.
*(9) Majors in junior year are in Animal Industry.
*(10) Have no formal "major" in Poultry Husbandry except that students especially interested have advisers in the department who help plan their courses of study.
*(11) B.S. in Home Economics students required to take general poultry husbandry if they expect to be in home demonstration work.
*(12) Cannot be taken in first year.
*(13) No technical "major" in poultry husbandry. Refers to number taking (all) advanced courses.
*(14) Students major in A. H. This includes some who in reality have had a major in poultry.
*(15) Required also for veterinary students.
*(16) Required also for Ag. Education students.
*(17) Do not aim to turn out many poultry majors. A number of students take a minor in poultry.
*(18) Department established only in 1936.
*(19) After graduation poultry majors must work a full year on the college poultry plant before being given a Poultry Specialist Certificate.
*(20) Have five groups as subdivisions of curriculum organization, a general course in poultry husbandry is required in two of these. All the several agriculture and vocational education groups must take poultry.

It should be stated in the beginning that the widely varying practices in the different colleges made a summary of this nature difficult, as indicated by the large number of notes required as an addendum to Table 1. It should be noted, too, that data refer only to the regular four year course in agriculture.

Twenty schools require a course in general poultry husbandry. In the majority of the others, this course is required for all except those specializing in certain fields. In Michigan, for example, it is required for all except majors in horticulture, landscape architecture, and forestry. In Utah, poultry is one of seven orientation courses. Six of the seven are required, and four of these must be taken in the first or second years. Only six states, Wisconsin, California, Colorado, Illinois, Massachusetts, and Minnesota, do not require general poultry for any students. Of course, in any of these, this would not apply to students electing a major or its equivalent in poultry husbandry.

Twenty-eight, or 68 percent, give this first poultry course in the first or second year. In some colleges introductory poultry cannot be taken before the third year. This is a decided disadvantage, from the standpoint of interesting students in poultry husbandry, because nearly all schools require that a major be elected by the beginning of the third year.

The variations in requirements for the general poultry course and in the years it is offered, may be due to the controversial nature of the question or to the fact that in each of our own colleges the set-up is often not our choice. In many colleges, the first two years of the agricultural curriculum are so crowded with required courses that to add a new one (as might be the case if general poultry were to be changed from the junior to the sophomore year), or even to change the semester or time of a course, involves conflicts, interdepartmental jealousies, or perhaps results of a more serious nature which never aid coöperation between departments. In the summer of 1930, when the poultry department of South Dakota State College was without a representative, the department of agricultural economics decided that such a time would be excellent to change their five-hour introductory course from the junior to the sophomore year. Because no one was there to represent the department, general poultry husbandry, a required course, was moved to the junior year. The result was that by the time students could take general poultry husbandry, they had selected their major and minor courses of study and the poultry department had little chance to secure poultry majors. It took more than two years to get the poultry course back to the sophomore year.

Smaller agricultural colleges have even a greater job of selling poultry husbandry to students because the financial support of the department is often based, not on the importance of the industry in the state, but on the number of students who take a major in the subject, or perhaps on how good a politician the particular department head may be. In another college, a major in poultry husbandry can be offered only when five students in one year elect a major in this subject. But county agents and Smith-Hughes teachers all over the state know that a poultry major is not now offered. Prospective poultry students are so advised and they decide to major in something else, or go to another college. Until a major in poultry husbandry is established for a few years, is the requirement of five students not, therefore, a serious disadvantage to that poultry department?

If general poultry husbandry is required, we do get, as Payne (1935) has shown, a number of students who are not interested in poultry. Lack of student interest, regard-

less of the teacher's ability, is requirement number one for a poor class. Is it not, however, the good teacher's job to change the uninterested?

On the other hand, we have today many county agents and a few Smith-Hughes teachers who are working now with our future agricultural college students but who have never had a course in poultry. Some of them, because of numerous demands for poultry work, have studied poultry since leaving school. Unfortunately many others still look on poultry as a very minor farm enterprise and, consequently, do not emphasize it in their work. These community agricultural leaders may even divert possible poultry major students into some other line. Regardless of the subject under discussion, telling a boy to major in this, that, or the other subject is first degree folly. The student should choose for himself, but perhaps not until he has had a fair chance to learn that he does or does not enjoy certain subjects.

Since most of our agricultural students come from rural areas, they have acquired a poultry prejudice because of the minor part poultry plays on so many farms. Some of these students might be interested in poultry husbandry through a good college teacher, but it is doubtful if any of this class would ever elect a course in poultry husbandry. Therefore, we are of the opinion that a general course in this subject should be required of all agricultural students.

The average credits for the general poultry course in 38 colleges were 2.58 on a semester basis, equivalent to 3.87 on a quarter basis. Delaware gives a six credit course on a semester basis; Georgia and Minnesota offer the other extreme, giving only a one credit course on a quarter basis.

To the writer's knowledge a fairly complete summary of the number of students taking a major or its equivalent in poultry has not been previously published. In the 1935-36 college year, in 22 and 24 colleges respectively, 109 juniors and 92 seniors majored in the subject. This is undoubtedly a very great increase over a few years ago; yet good students are having no difficulty in finding suitable employment.

SUMMARY

1. A course in general poultry husbandry is regularly offered in the state college or university of 41 states which answered the survey.

2. Twenty schools require this course. In the majority of the others, general poultry husbandry is required of all agricultural students except those specializing in a few certain fields. Only six states do not require a course in poultry for any agricultural students.

3. Sixty-eight percent of the colleges offer general poultry in the first or second year.

4. The average credits for the introductory poultry course were 2.58 on a semester basis.

5. Only four out of 41 colleges did not offer a major or its equivalent in poultry husbandry or industry.

6. In the 1935-36 college year, a total of well over 200 junior and senior students were taking a major or its equivalent in poultry.

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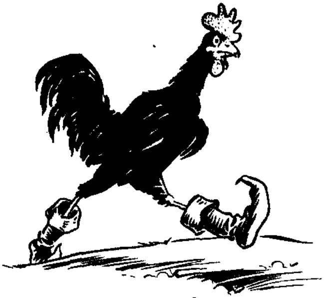

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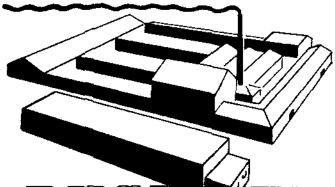

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